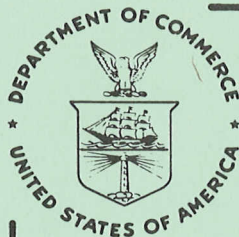


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Biological/Chemical Survey of Texoma and Capline Sector Salt Dome Brine Disposal Sites Off Louisiana, 1978-1979

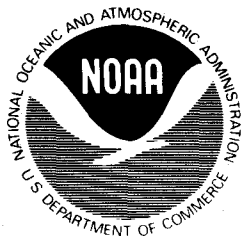
A report to the Department of Energy on work conducted under provisions
of Interagency Agreement EL-78-I-O-7146 during 1978-1979.

Volume I BENTHOS



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Center
Galveston Laboratory
Galveston, Texas 77550

NOVEMBER 1980



NOAA Technical Memorandum NMFS-SEFC- 25

Biological/Chemical Survey of Texoma and Capline Sector Salt Dome Brine Disposal Sites Off Louisiana, 1978-1979

VOL. I DESCRIBE LIVING AND DEAD BENTHIC (MACRO-MEIO-) COMMUNITIES BY

**R.H. Parker, Ph.D., A.L. Crowe, and L.S. Bohme
Coastal Ecosystems Management , Inc.
3600 Hulen
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**A report to the Department of Energy on work conducted under provisions
of Interagency Agreement EL-78-I-O-7146 during 1978-1979.**

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Volume I - BENTHOS

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I. EDITORS' SECTION

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LIST OF VOLUMES

This Final Report is printed in nine separate volumes:

Volume I - BENTHOS

Work Unit 2.1 Describe Living and Dead Benthic (Macro- and Meio-) Communities

Coastal Ecosystems Management, Inc.

R. H. Parker, Ph.D.

A. L. Crowe

Volume II - ZOOPLANKTON

Work Unit 2.2 Determine Seasonal Abundance, Distribution and Community Composition of Zooplankton

LGL Ecological Research Associates, Inc.

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Volume III - BACTERIA

Work Unit 2.3 Describe Bacterial Communities

Texas A & M University

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Volume IV - DEMERSAL FISHES AND MACRO-CRUSTACEANS

Work Unit 2.4 Determine Seasonal Abundance, Distribution and Community Composition of Demersal Finfishes and Macro-crustaceans

Texas A & M University

A. M. Landry, Ph.D.

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Volume V - SEDIMENTS

Work Unit 3.1 Describe Surficial Sediments and Suspended
Particulate Matter

Energy Resources Company, Inc.

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Volume VI - HYDROCARBONS

Work Unit 3.2 Determine Hydrocarbon Composition and
Concentration in Major Components of the
Marine Ecosystem

Energy Resources Company, Inc.

P. D. Boehm, Ph.D.

D. L. Fiest

Volume VII- TRACE METALS

Work Unit 3.3 Determine Trace Metal Composition and
Concentration in Major Components of the
Marine Ecosystem

Southwest Research Institute

J. B. Tillery

Volume VIII - INORGANIC NUTRIENTS

Work Unit 3.4 Determine Seasonal Variations in Inorganic
Nutrients Composition and Concentrations in
the Water Column

Texas A & M University

J. M. Brooks, Ph.D.

Volume IX - SHRIMP DATA ANALYSIS

Work Unit 5.1 Analysis of Variance of Gulf Coast Shrimp Data

LGL Ecological Research Associates, Inc.

F. J. Margraf, Ph.D.

INTRODUCTION

In compliance with the Energy Policy and Conservation Act of 1975, Title 1, Part B (Public Law 94-163), the Department of Energy (DOE) implemented the Strategic Petroleum Reserve (SPR). The SPR program was implemented in August of 1977 with the goal of storing a minimum of one billion barrels of crude oil by December 22, 1982. After evaluating several physical storage possibilities, DOE determined that storage in commercially developed salt dome cavities through solution-mining processes was the most economically and environmentally advantageous option.

Six areas along the northwestern Gulf of Mexico were to be investigated as potential storage cavern sites. These areas are shown in Figure 1. This project, "Biological/Chemical Survey of Texoma and Capline Sector Salt Dome Brine Disposal Sites Off Louisiana", deals with proposed disposal sites associated with two of the cavern sites, West Hackberry and Weeks Island. The Biological/ Chemical Survey was initiated in April 1978 and was completed in December 1979. Its major products are Final Reports available through the National Technical Information Service (NTIS), Springfield, Virginia; data files available through the Environmental Data and Information Service (EDIS), Washington, D.C., and any research papers that may be written by participating principal investigators and published in scientific or technical journals. Preliminary results were also made available through DOE/NOAA/NMFS project reviews and workshops attended by project participants and various governmental, private and public user groups.

The objectives of the Biological/Chemical Survey were: (1) to describe the biological, physical and chemical components of the marine ecosystem for each disposal site; and (2) to assess, by analysis of Gulf Coast shrimp data, the importance of the Louisiana shrimping grounds in the vicinity of the proposed salt dome brine disposal sites. These objectives were achieved using historical and new data to describe and quantify the biological, chemical, and physical characteristics and the temporal variations of these characteristics in the environments of each proposed disposal site.

The two proposed disposal sites have been extensively examined, using available meteorological, oceanographic, bathymetric and ecological data, in the following two reports:

Environmental Data Service, DOC/NOAA. 1977.

Analysis of Brine Disposal in the Gulf of Mexico, #2 West Hackberry. Report to Federal Energy Administration Strategic Petroleum Reserve Program Salt Dome Storage. Center for Experiment Design and Data Analysis, NOAA, EDS, Marine Assessment Division, Washington, D.C.

Environmental Data Service, DOC/NOAA. 1977.

Analysis of Brine Disposal in the Gulf of Mexico, #3 Capline Sector. Report to Federal Energy Administration Strategic Petroleum Reserve Program Salt Dome Storage. Center for Experiment Design and Data Analysis, NOAA, EDS, Marine Assessment Division, Washington, D.C.

The above reports and other pertinent documents are available from the Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia, 22151.

Proposed locations of the West Hackberry (Texoma Sector) and Weeks Island (Capline Sector) brine disposal sites are shown in Figures 2 and 3, respectively. These sites are subject to change within the same geographic area pending results of baseline surveys presently underway.

The proposed West Hackberry disposal site is located approximately 9.7 km (6 miles) south off the coast from Mud Lake at Latitude $29^{\circ}40' N$ and Longitude $93^{\circ}28' W$ at a bottom depth of about 9 m (30 feet). Operational requirements and engineering limitations of the proposed brine diffuser at this site are as follows: length - 933.3 m (3070 feet); orientation -normal to coast; number of ports - 52; length between ports - 18 m (59 feet); port diameter - 7.6 cm (3 inches); orientation of port riser - 90° to bottom; and port exit velocity - 7.6 m/sec (25 ft/sec).

The proposed Weeks Island (Capline Sector) disposal site is located approximately 41.8 km (26 miles) off Marsh Island at Latitude $29^{\circ}04' N$ and Longitude $91^{\circ}45' W$ at a bottom depth of about 9 m (30 feet). Operational requirements and engineering limitations of the proposed brine diffuser at this site are as follows: length - 608 m (2000 feet); orientation -normal to coast; number of ports - 34; orientation to port riser - 90° to bottom, and port exit velocity - 7.6 m/sec (25 ft/sec).

The Biological/Chemical Surveys in the proposed salt dome brine disposal sites described seasonal abundance, distribution and community

composition of major benthic, planktonic, bacterial and demersal finfish and macro-crustacean ecosystem components; the sediments; the hydrocarbons and trace metals composition and concentration in the marine ecosystem; and the seasonal variations in inorganic nutrients composition and concentration of the water column. The sampling scheme used for sample collections around the two sites is shown in Figure 4. A separate data analysis assessed the importance of shrimp-ing grounds in the vicinity of the proposed brine disposal sites in terms of historical data on species composition, marketing size categories and location of commercial shrimp catches within statistical reporting zones off the Louisiana coast.

Information concerning data from this project is available through the Program Data Manager: Mr. Jack Foreman, Environmental Data and Information Service, Page Building No. 2, 3300 Whitehaven Street, N.W., Washington, D.C.

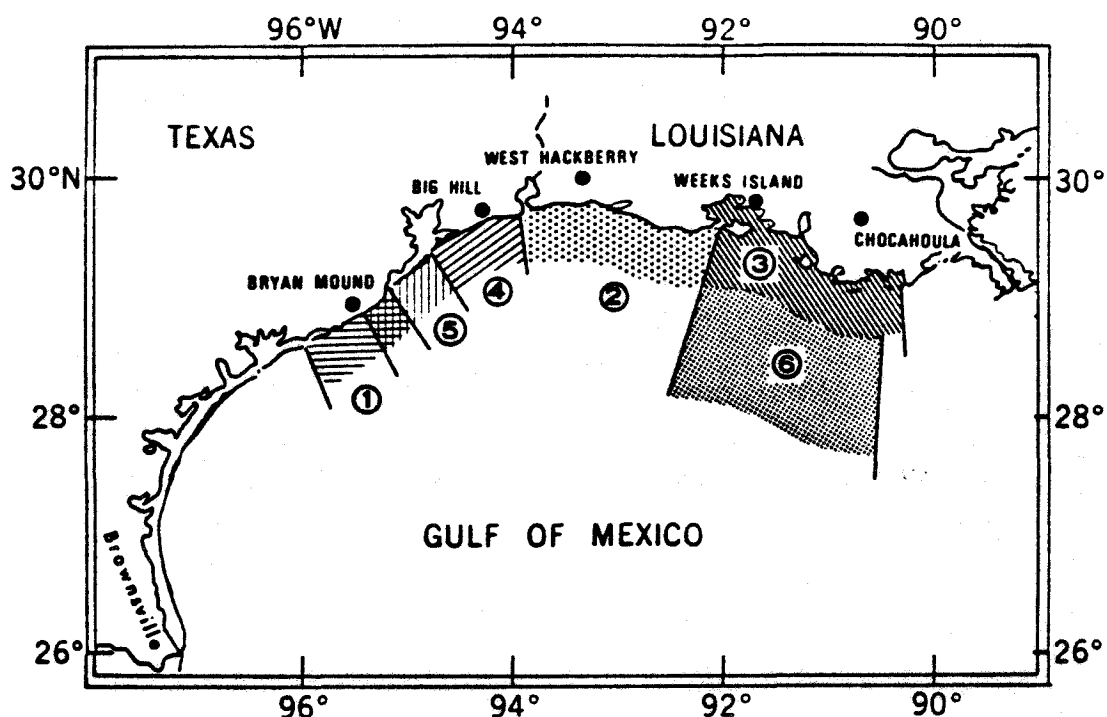


Figure 1. Regions of Study for Brine Disposal Assessment-DOE/NOAA Interagency Agreement (adapted from Environmental Data Service, DOC/NOAA. Analysis of Brine Disposal in the Gulf of Mexico, #2 West Hackberry. 1977.).

- 1 Texas Coastal Ocean, Colorado River to San Luis Pass (Bryan Mound)
- 2 Louisiana Coastal Ocean, Sabine Lake to S.W. Pass of Vermilion Bay (West Hackberry)
- 3 Louisiana Coastal Ocean, S.W. Pass, Vermilion Bay to Timbalier Island (Capline Sector)
- 4 Texas Coastal Ocean, Port Bolivar to Sabine Pass
- 5 Texas Coastal Ocean, Freeport Harbor to Galveston South Jetty
- 6 Louisiana Coastal Ocean, Offshore from Vermilion Bay to Terrebonne Bay

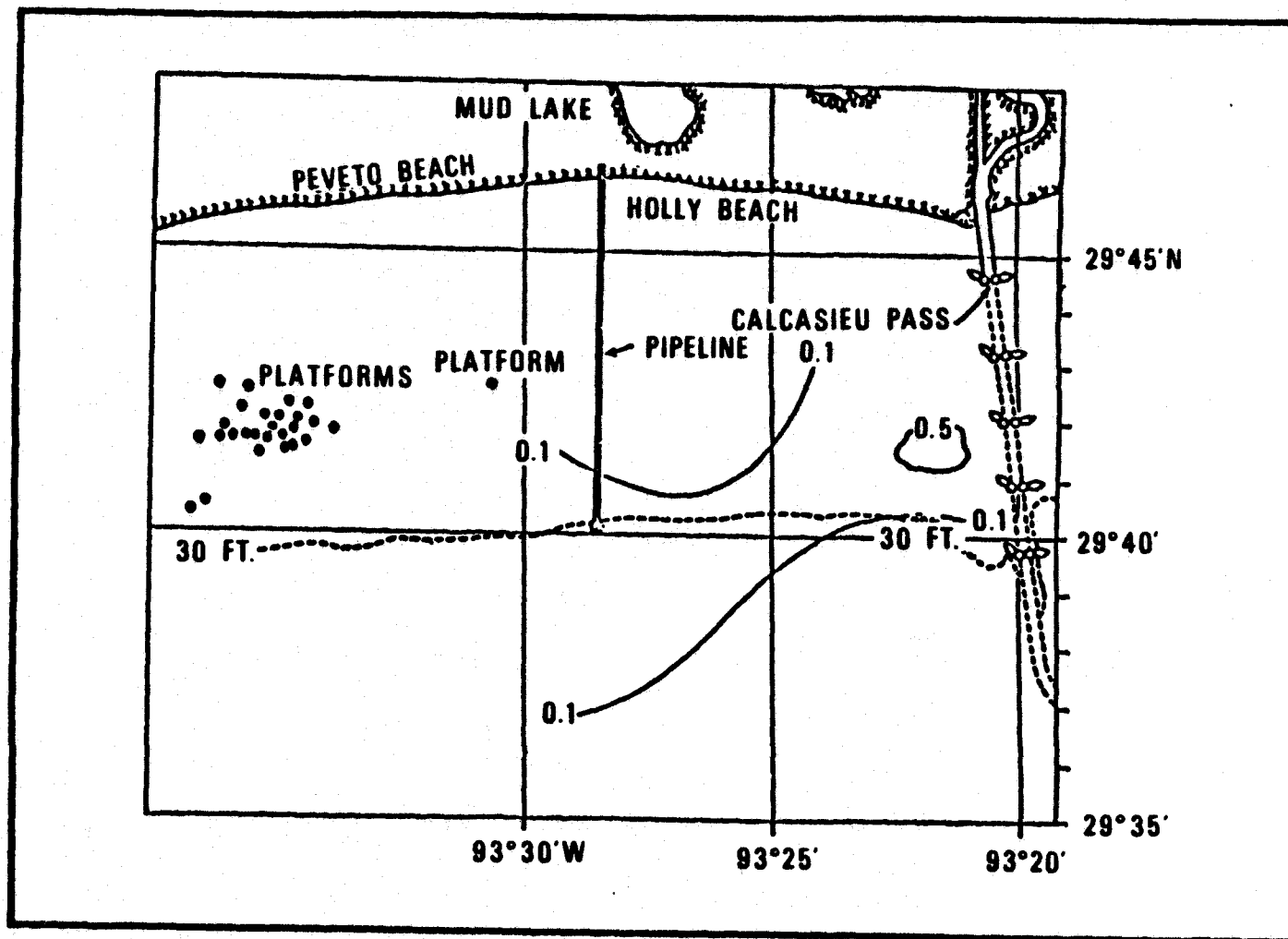


Figure 2. Proposed Texoma brine disposal site.

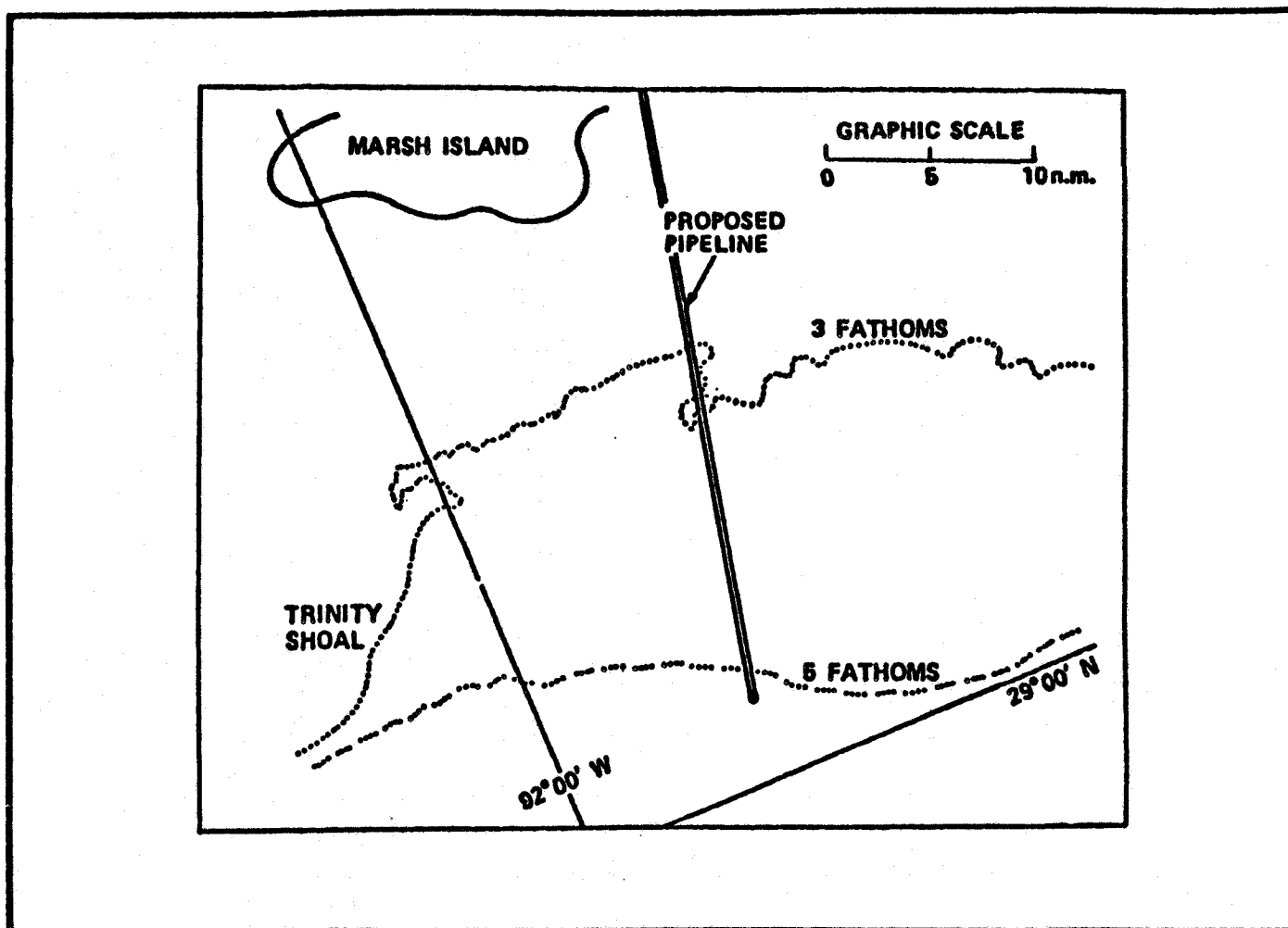


Figure 3. Proposed Capline brine disposal site.

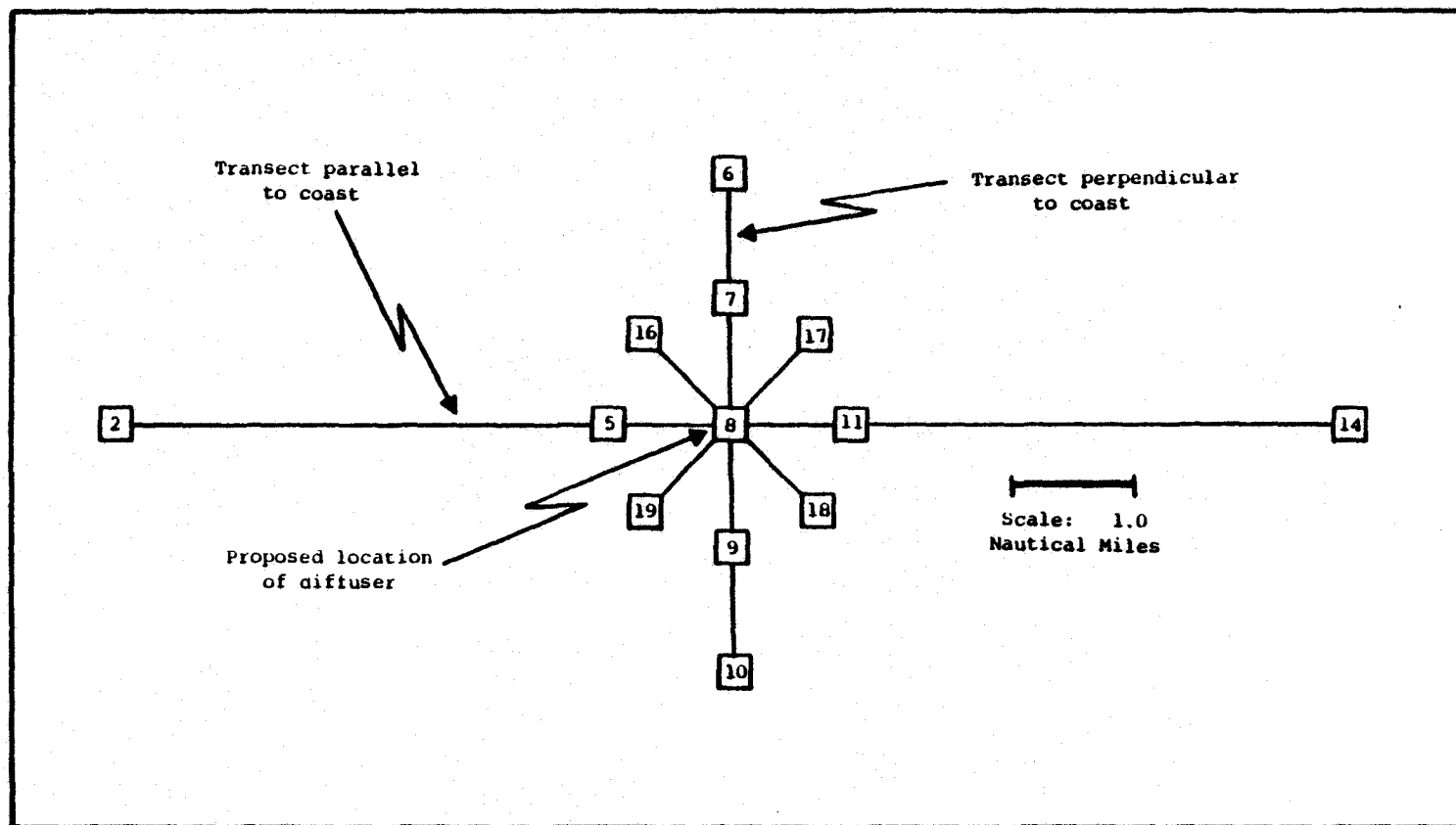


Figure 4. Sampling scheme for proposed salt dome brine disposal sites.

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II. PRINCIPAL INVESTIGATORS' SECTION

**WORK UNIT 2.1 - DESCRIBE LIVING AND DEAD BENTHIC (MACRO- AND
MEIO-) COMMUNITIES**

**R. H. Parker, Ph.D
A. L. Crowe
and
L. S. Bohme**

Coastal Ecosystems Management, Inc.

ABSTRACT

A baseline survey of megabenthic and meiobenthic assemblages near two proposed brine disposal areas was conducted from June 1978 through May 1979. The polychaete Paraprionospio pinnata and the pelecypod Mulinia lateralis dominated the megafauna at the West Hackberry site. The polychaete Mediomastus californiensis and the pelecypod M. lateralis dominated the megafauna at Weeks Island site.

Temporal changes occurred in species composition and abundance at both sites. Numbers of individuals per square meter were lowest in the summer at West Hackberry and in winter at Weeks Island, and highest in the spring at both sites. The nearshore benthic community had a rapid turnover rate, and most species completed their life cycles in a year or less.

Both sites were characterized by low dissolved oxygen values during the summer cruise. The passage of tropical storm DEBRA drastically reduced the numbers, biomass, and diversity at Weeks Island. The West Hackberry site supported a greater number of individuals and biomass than the Weeks Island site, but it had a lower species diversity.

Nematodes dominated the meiobenthos at both sites, while other components, especially the environmentally sensitive peracarid Crustacea, were rare or lacking. Lack of diverse meiobenthos at both sites suggests an overall variable and adverse environment.

Little correlation between faunal abundance or diversity and sediment type or bacteria counts was found at the station, site, or seasonal level, although community composition differed considerably between the two sites. The inference suggested is that abundance and diversity are random but unique for each overall site, suggesting sampling pattern or frequency is relatively unimportant in determining average production for the region only.

Inspection of various descriptive statistical indices for each site on a station basis over an annual cycle suggests that poorest quality stations at West Hackberry were stations 8, 16, and 17--all in the vicinity of the proposed diffuser location. Comparative quality of stations at Weeks Island is relatively random, with only two stations (stations 2 and 10, farthest from the diffuser site) with consistently low indices.

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INTRODUCTION

This study was undertaken to ascertain the structure and composition of the benthic communities in two nearshore areas of the northwest Gulf of Mexico that may be affected by the effluent of proposed salt brine diffusers. Benthic animal studies are of particular importance in assessing the overall community structure of an ecosystem in that these animals are a vital link in the food chain of a majority of fish and crustaceans in the northwestern Gulf of Mexico. Moreover, due to their largely nonmotile existence, they make excellent subjects by which to gauge man's impact on a natural ecosystem. Benthic populations are assumed to be affected by a number of natural conditions; such as, bottom sediment grain size, dissolved oxygen in bottom waters, storm surges, and seasonality of salinity and water temperature. Major or sudden fluctuations in any physical-chemical parameter could cause a change in site specific or regional population composition. Therefore, it is of particular importance to sample for as many seasons and for as many different years as possible in order to understand how some of these naturally occurring environmental changes affect the benthos of a particular area. Once these natural deviations are understood, a better grasp can be made of what man's effects on the ecosystem will be.

This study covers the results of sampling two sites during each of the four seasons from summer 1978 through spring 1979. The two sites represent two distinctly different environments. West Hackberry site (Texoma) is located in 30 feet of water, approximately 6 miles south of Mud Lake near the Texas-Louisiana border. The sediment there ranges from clay to sandy-silt. Weeks Island site (Capline) is in 30 feet of water and is located approximately 26 miles offshore of Marsh Island, Louisiana,

halfway between Trinity and Ship Shoals (Appendix Figure 1). The Atchafalaya River, a major component of the Mississippi River system, empties directly north-northeast of the sampling site and seasonally makes a direct and major influence on water measurements at the site. The Weeks Island site is distinctly sandier (>70% sand) than the West Hackberry sit (<40% sand) (Hausknecht 1980).

The offshore benthic community of the Texas-Louisiana coast has been sampled recently by Texas A&M University (TAMU); Science Applications, Inc. (SAI); and Dames and Moore, Consulting Engineers. Coastal Ecosystems Management, Inc. (C.E.M.) was subcontracted by SAI to collect the benthos at five different sites, one site of which was only 2.5 nautical miles to the east of the present West Hackberry site. Sampling for that study was done on a monthly basis from the summer of 1977 through the summer of 1978.

METHODS AND MATERIALS

Two stainless steel Van Veen grabs, one weighing 20 lbs and sampling approximately $1/20 \text{ m}^2$ and the other weighing 30 lbs and sampling approximately $1/19 \text{ m}^2$, were used to take triplicate samples at each of 13 stations for four separate seasons at Weeks Island and West Hackberry (Appendix Figures 2 and 3, respectively). A full grab sample penetrated the sediment approximately 10-cm deep. The samples from West Hackberry usually came up full, but due to the difficulty in penetrating the sandy sediment at Weeks Island, the grabs taken there rarely came up over half filled. As a result, volumetric comparisons between the two sites are impossible. Areal comparisons, however, were made.

Subsamples for meiofauna were obtained before placing a grab into the plastic buckets. A plastic coring tube (diameter 3.5 cm, area 10 cm^2)

was pushed perpendicularly into the sediment and a minimum (5 cm) sample of sediment was removed for the subsample. This was fixed with 7% formalin and stained with rose bengal. Previous investigations have shown that about 95% of the meiofauna are found in the upper 5 centimeters of sediment (Muus 1964; Tietjen 1968).

Grab samples were placed in plastic buckets and washed, using sea water filtered through a 500 μ screen, while on board ship. The samples were fixed in approximately 7% formalin and stained with rose bengal to aid in later separation of live animals from dead shells or tests.

Once in the laboratory, megafauna samples were elutriated and resieved to remove those organisms that floated (polychaetes, small crustaceans, etc.), while the more dense animals (mollusks, etc.) were removed by hand with the aid of a lighted magnifying glass. Organisms were then sorted under a dissecting scope; counted; and, where possible, recorded to species level. Means and standard deviations for each station were obtained from analyzing the three replicate grabs, and coefficients of variation were calculated between all samples of all stations (Appendix Tables 1, 2, and 3).

Taxonomic keys that were used included: actiniarians (Carlgren and Hedgpeth 1952), amphipods (Bousfield 1973), annelids (Hartman 1945, 1951; Fauchald 1977; Pettibone 1963), larval polychaetes (Rasmussen 1973), decapods (Felder 1973; Voss 1955; Schmitt 1935; Powers 1977; Wood 1974; Williams 1965), isopods (Menzies and Frankenberg 1966), nemerteans (Coe 1951), planktonic copepods (Newell and Newell 1963), mollusks (Andrews 1971; Emerson and Jacobson 1976), fish (Parker 1972), and general invertebrates (Smith 1964; Watling and Maurer 1973). Identifications of some of the polychaetes were checked for accuracy by Dr. Donald Reish of

Reish Marine Studies, Inc. of Los Alamitos, California.

Wet weight biomass determinations were made on an analytical balance for all organisms picked, including shell material. Individual organisms (e.g., starfish) that weighed over 1.5 grams were not included in biomass determinations, as these animals were extremely patchy in distributions and would mask true biomass values. Individual station or sample biomasses are not included, but can be obtained from the National Oceanic and Atmospheric Administration, Environmental Data and Information Service, Center for Environmental Assessment Services (NOAA/EDIS).

Meiofauna subsamples were elutriated in the lab and sieved through 500 μ and 63 μ screens. The portion that was caught on the larger screen was added to the megafauna sample, and the portion that was retained on the 63 μ screen was examined through a compound microscope, using 54X which was judged sufficient to see the smallest nematodes, tardigrades, and kinorhynchans. All samples and study collection specimens are maintained by C.E.M. in labeled vials for later use as a study or reference collection at C.E.M., or to be transferred under chain-of-custody regulations to a government agency.

Hydrographic measurements were taken from the surface to the bottom at one-meter intervals at each station. These measurements (water temperature, conductivity, pH, depth, and dissolved oxygen) were taken with a Hydrolab Surveyor that measured the variables with an in situ probe and were recorded from a deck readout. The dissolved oxygen values were corrected for salinity, and the conductivity readings were converted to salinity values. The Hydrolab Surveyor was sent to the Office of Marine Technology, Test and Evaluation Laboratory, Washington, D.C., for calibration, but was returned to C.E.M. uncalibrated because the

instrument was needed for the winter cruise. Calibration was undertaken at C.E.M. and procedures were followed as recommended by the manufacturer. All data are on file with NOAA/EDIS.

Statistical Analysis Techniques

The first statistic calculated had to be abundance and diversity by station in that three replicate samples were taken at each station, at each site, and during each season. The figures used for additional statistical analysis were the mean and standard deviation calculations for each station (3 samples) rather than data for individual samples. Data by species are recorded here as all individuals (for all three samples) per station, since mean species level data often will consist of fractions of individuals. Counts of each species from each station can be obtained from NOAA/EDIS where all raw data are on file.

In order to ascertain the reliability of our data, based on triplicate samples, Student's t-test, F test, and coefficients of variation were calculated. First, the mean and standard deviation of each set of samples at each station were calculated for total counts of all organisms for both megafauna and meiofauna (Appendix Tables 1 and 2). The standard deviation (SD) reveals the degree of variation in the triplicate samples which, for megafauna, ranges from 10 to 60 percent difference between samples. Averages of the standard deviations in relation to total populations per station, site, and season were calculated as coefficients of variation (Appendix Table 3). It is significant that on the basis of total number of animals alone, variability is very low for megafauna and reasonable for meiofauna. For instance, the coefficient of variation of megafauna at both West Hackberry and Weeks Island differs by 0.01, only. Regardless of the real difference in diversity and total populations

between the two sites, the variation is the same, which substantiates the contention that triplicate samples (and probably a single sample) describes the population levels adequately.

Coefficients of variation for meiofauna are much higher (more variable) as evidenced by values twice those of the megafauna. The high variability between samples is probably related to the fact that numbers of meiofauna are related to size and amount of particulate food sources in the sediment. This conjecture is supported by a study on variation of meiofauna populations in a large number (30 to 50) of closely spaced core tube samples taken between January 1955 and March 1956 in San Francisco Bay (Jones 1961), and in a similar multiple core sample study performed off Scripps Institution of Oceanography's beach (Fager 1963). Distribution of meiofauna tends toward aggregation around food sources; i.e., nematodes and other detritivores that cluster around a decaying food source or particle. This type of distribution, therefore, is nonrandom with very low chances of obtaining replicate numbers, especially when the sample area is 10 cm^2 and the sampling plot is close to 1000 m^2 .

On the other hand, the distribution of megafauna, or larger benthic animals, tends to be more random, especially when all other factors are relatively uniform over 100 m^2 and a number of different trophic levels are represented. Previous sampling at the two sites (C.E.M. and SAI, 1977-1978 unpublished data) indicates a single, low-diversity, highly uniform population of megafauna at both sites, accounting for low variance in population numbers (high similarity) between replicate samples at the same station. According to Jones (1961), aggregation rather than random distribution is characteristic of the really abundant or predominant species. This is certainly true for nematodes in the meiofauna, and

certain species of polychaetes and Mulinia lateralis in the megafauna.

All diversity statistics were calculated from the sum of the three replicates at each station (having determined previously the levels of variation between samples) and then seasonal means were calculated for each site from the thirteen different stations. A number of statistical indices were calculated in an effort to obtain quantitative data on the community structure of the benthic fauna present at the two project sites. These indices include the following:

(1) The Shannon-Weaver diversity index, as stated in Lloyd, Zar, and Karr (1968), was calculated for each sample:

$$H' = -\sum p_i \log_{10} p_i$$

where

$p_i = n_i/N$ and n_i is the number of individuals in species i , and N is the total number of individuals counted.

(2) Species evenness was calculated for each sample according to Pielou (1975).

$$J' = \frac{H'}{\log S}$$

where

H' is the value of the Shannon-Weaver index and S is the number of species at a given station.

(3) Species richness was calculated according to Margalef (1958).

$$SR = S - 1/\log N$$

where

S is the number of species per station and N is the number of individuals counted.

(4) The Bray-Curtis similarity index (Clifford and Stephenson 1975) was used to measure the similarity between stations within a site. It indexes two stations at a time and measures both the similarity of species and the similarity of individual counts within similar species groups. It is expressed by the following formula:

$$S_{jk} = \frac{\sum_{i=1}^n |X_{ij} - X_{ik}|}{\sum_{i=1}^n (X_{ij} + X_{ik})}$$

where

X_{ij} is the number of individuals of species i at station j ; X_{ik} is the number of individuals of species i at station k , and n is the number of species. The Bray-Curtis similarity index was run on the same m gafauna (triplicate samples lumped) data which were used to determine similarity between stations. The lower the Bray-Curtis value the greater the similarity between stations.

The other tests that were carried out for significant differences between stations, sites, and seasons were Student's t-test and F test. The results of the tests between all stations at each site by season are given in Appendix Tables 4 and 5. Note that values revealed by the t-test of significant differences in means between seasons indicate that results from only the winter and spring sampling at West Hackberry were statistically similar as to mean population (Appendix Table 4).

Homogeneity of variance between stations, sites, and seasons, using the F test as evidence, showed homogeneous variance between fall and summer at West Hackberry. On the other hand, the summer and winter as well as the fall and winter sampling at Weeks Island showed homogeneous

variance (Appendix Table 5).

RESULTS AND DISCUSSION

Introduction

Upon casual inspection, certain environmental factors appeared to regulate or be closely correlated with total populations and diversity of megafauna and meiofauna. Those factors which appeared to be highly correlated were total population of megafauna and sediment type, and meiofaunal counts versus bacterial populations, thus emphasis was placed on determining true correlations between total counts, diversity, and sediment size parameters derived from data obtained in Hausknecht (1980), and faunal counts versus aerobic bacterial counts as given in Schwarz, Alexander, Schropp, and Carpenter (1980). In order to validate these apparent relationships, simple correlation coefficients were calculated on both station and site bases by season. Unfortunately, counts of anaerobic bacteria were not made, and it is possible that these organisms may be the primary sources of food for meiofauna, thus correlations could not be made with anaerobic bacteria. The results of the correlations that were calculated are not included because they were not statistically significant.

Some data (SAI, unpublished data) are available from other aspects of the Strategic Petroleum Reserve (SPR) environmental sampling program, and these data were examined for apparent relationships which might affect benthos at the Texoma site. However, it was not within the scope of required work nor the intent of C.E.M. to carry out a full ecological study of benthic fauna as related to all other facets of this and other sampling programs. For this reason, the bulk of this present discussion

is concerned only with relative changes in numbers, diversity, and individual taxa within the samples taken throughout the seasonal program. Explanations for seasonal and areal variations in megafauna and meiofauna can be found only when all results of the Strategic Petroleum Reserve environmental investigations are examined. Results are discussed first by site and then as a set of overall relationships of benthic standing crops as to their use in determining the environmental effects of open water brine disposal.

The level of observation used for ascertaining baseline conditions may not be frequent enough for total monitoring of impacts of brine disposal. The senior author has examined the fluctuations and vagaries of benthic populations in a very small area at a frequency of once a week for nearly two years (Parker 1975), and once a month for 10 months during the SAI study which preceded this present one. Although details from available studies were revealed concerning reproduction, predation, and rates of change in standing crops of megafauna and meiofauna at the weekly, monthly, and seasonal levels, a firm recommendation for sampling periodicity for further baseline and monitoring studies cannot be formulated until data from all contract sources are integrated.

Biotic interactions and fluctuations of populations of benthos resulting from heavy larval sets are evident at the weekly sampling level and can be interpreted from data collected on a monthly basis. On the other hand, our quarterly or seasonal sampling for benthos did reveal community composition, dominance, comparative diversity, and standing crop numbers, not very different from those obtained on a monthly basis. It appears from this series of observations that weekly ecological observations reveal biotic interaction and subtle relationships of species

to physicochemical factors; monthly observations reveal major reproductive replacement rates and to some extent productivity; while seasonal sampling reveals average standing crop (population density) and average community composition, as well as seasonal species replacement. Sampling interval and timing, therefore, is determined by the questions that need answers.

Damage assessment for any marine biotic community or resource is difficult to prove as to exact cause. Aside from direct observation of animals dying in a pool of oil or frothing chemicals, causes for disappearance of life, or later observations of lowered standing crop, are almost impossible to establish. So many factors are at work in maintaining a steady and normal utilization of available resources in complex marine ecosystems that simplistic interactions--such as, change in salinity, temperature, oxygen, pH, hydrocarbon content, or any of a dozen factors singled out as causes of pollution--cannot be used to assess damage causes. Simple or complex ecological models may show that changes in variables which are known to affect life processes can change population density or diversity. However, unless all lethal factors can be examined first hand, a model output must still be considered hypothetical, especially if only a few samples of the population have been counted, or a few variables have been measured. Subtle changes, such as salinity increases, in a small area, or an increase in metallic ions or certain hydrocarbons could change aspects of a normal marine ecosystem, except that normal operations of any complex marine (especially estuarine) ecosystem are not known in sufficient detail for detection of damages.

If one expects to isolate causes for minor or barely observable changes in resource production, the degree of premonitoring and post-monitoring efforts must match the level of predicted change. In virtually

all cases of monitoring, other than that of a static aquaria, the levels of observation are severely limited. For this reason, ecologists select those factors for observation that may cause the greatest change in the largest number of associated correlated variables. It is assumed that this methodology will be employed upon later analysis of these data.

In the case of monitoring the two proposed brine disposal sites, it is necessary to determine now what data have been obtained that fits the set of criteria for establishing damage causalities, and then establish new criteria for monitoring efforts. Since all data collected during the past two years are not available, it is not possible to establish probable levels of inspection, future sampling, or prediction of damage. Certainly, four sampling periods a year with widely-spaced samples taken in only two small areas is insufficient for small compartment level of cosystem damage assessment. On the other hand, weekly observations from hundreds of closely-spaced samples over large areas, although ideal scientifically, are financially totally impractical. In all probability, a compromise must be struck as to sampling interval and intensity. Such decisions can be made by those with all data in hand, and with the historical biological perspective that would enable one to make knowledgeable decisions. Based on the results of benthic studies, alone, sampling on a monthly basis with a closely-spaced pattern in the immediate vicinity of the diffuser site seems to be a reasonable monitoring program.

Megabenthos

West Hackberry Site

Polychaete species are the predominate components of the megabenthic community at West Hackberry (Appendix Table 6). The most abundant benthic animals present in the summer were the polychaete species Paraprionospio pinnata and Magelona sp. This changed in the fall to P. pinnata and Sigambra tentaculata. In the winter and spring, the mollusk Mulinia lateralis and the polychaete Cirriformia sp. predominated (Appendix Table 7).

The nemertean Cerebratulus lacteus is an important predator in this ecosystem and their numbers follow closely the increase and decrease in standing crop of soft bodied organisms (total g/m² minus Mulinia g/m²) (Appendix Figure 4). The brittle star Micropholis atra and the pinnotherid crabs were seasonally important scavengers (Appendix Table 8).

A few juvenile penaeid shrimp, Penaeus setiferus, were taken in the grabs, except during the spring. Their mean length was 10 mm in the summer and fall, and was 35 mm during the winter. This size class of individuals and their increase in size does point to the possibility of the use of the nearshore Gulf as a winter nursery ground, although such a small sample is not statistically significant for such predictions.

An extremely large settlement (site $\bar{x} > 8800/\text{m}^2$) of 1 to 3-mm length dwarf surf clam, M. lateralis, took place during the winter sampling. By spring, their size had increased to 4 to 6 mm, and their mean numbers had reduced to $> 3200/\text{m}^2$. Therefore, in the first three months after settling out of the plankton, the M. lateralis had an apparent growth rate of approximately 1 mm per month and a reduction in numbers of 37 percent. Mean standing crop estimates were made on 22 grabs that had M. lateralis

present. An almost fivefold increase in the standing crop biomass of M. lateralis was noted from winter through spring (28.35 g/m² to 135.59 g/m²). However, the lack of information regarding immediate survival, predation, and additional settling, because of the infrequent sampling frequency of twice in six months, precludes information on production or biotic interactions. Unfortunately, the SAI sampling program ceased during the critical spring months (1 April to 1 July 1978), and there is only one sampling period in May 1979 for assessing settlement success. A similar one time, large-number sampling of Mulinia (SAI, unpublished data) occurred in late September 1977 at West Hackberry, but most of that year-class had disappeared by the late October sampling. The Mulinia observed in 1977 were larger in size than those taken in June 1979, but smaller than the winter individuals. The fact that after October 1977, Mulinia were scarce at West Hackberry until December 1978, but remained abundant in 1979, suggests that not enough can be deduced from present available data concerning the population dynamics of that species.

Mulinia are deposit feeding suspension feeders. They use their exhalant siphons to stir up the fine flocculent layer and filter out organic matter and phytoplankton (Parker 1975). Those individuals that settle out of the plankton in the winter are presumed to be sexually mature by the end of summer. When small, their shells are easily crushed and they are fed upon by a variety of fish and crustaceans. Once their shells harden, predation requires the feeding methods of a fish with crushing jaws, such as the black drum (Pogonias cromis), or a predacious gastropod like Polinices duplicatus or Nassarius acutus. An increase in the number of juvenile Polinices was noted during the spring (Appendix Table 8), while the standing crop of Mulinia was at its greatest. At the West Hackberry site, during the summer, only eight live Mulinia were found,

although many adults were found whose shells were filled with mud. From the data gathered, it is estimated that over 99 percent mortality occurs in Mulinia from year to year. This comment is supported by the 1977-78 SAI data. Mulinia range from Prince Edward Island, Canada, to Yucatan, Mexico, in virtually every kind of sediment and in salinities from 5 ‰ to 80 ‰ (Parker 1956). As Mulinia never attains large numbers where competition from other species is prevalent, they are considered an indicator of environmental adversity (Parker 1975; 1976). This stress might be in the form of high sedimentation rates and fluctuations in temperature and salinity associated with the nearness of a river system. The sediment analysis suggests that the West Hackberry site and, to some degree, the Weeks Island site are areas of actively depositing sediments and are frequently anoxic (Hausknecht 1980).

The dissolved oxygen in the bottom meter of water was very low in June 1978 (<1 ppm at West Hackberry and <3 ppm at Weeks Island) (Appendix Table 9 and Appendix Figures 5 and 6), and could have been lowered beyond the tolerance limits of many benthic animals if it remained low for a prolonged period. Data collected in 1977 by C.E.M. (but two weeks earlier in the month than the present 1978 project's summer cruise) revealed that a large area of the nearshore Gulf was anoxic then. The bottom waters were almost totally anoxic from 2.5 nautical miles east of the center station at West Hackberry to 40 nautical miles west (Coastal Ecosystems Management, Inc., 1977 unpublished data).

Most of the predominant benthic animals in the area have larval planktonic stages that settle out in the fall and winter. This would enable the repopulation of areas that were subjected to environmental stress during the summer--such as, low dissolved oxygen or tropical storm

surges. The numbers of individual taxa at West Hackberry (Appendix Figure 7) showed an increase from a summer low to a winter peak.

The species diversity (H') at West Hackberry was relatively stable from season to season, although low when compared to Weeks Island (Appendix Table 10). An examination of diversity index data by station and season (Appendix Tables 11 and 12) show uniformly low values (H' below 1.0) for West Hackberry summer sampling, and slightly higher values (H' above 1.0) for some stations during fall and winter sampling. Higher station values are characteristic for Weeks Island summer sampling (all H' over 0.90) than for spring sampling where H' values over 0.90 were found at only three stations. Relatively low values for diversity were characteristic of stations 16 and 17 and for all inshore stations at West Hackberry, and at stations 2 and 10 at Weeks Island. It is significant that H' values below 0.65 were calculated for all inshore stations at West Hackberry--low even for estuaries; whereas only at station 10 (the station farthest from shore) at Weeks Island is H' below 0.77. Values for H' above 0.86 (\log_{10} as converted from the \log_e used by the referenced authors to the common log used in this report) are indicative of areas of clean estuarine waters (Holland, Maciolek, and Oppenheimer 1973). Based on the Holland et al. (1973) comment, West Hackberry H' values appear to be lower than those characteristic of clean estuarine waters, while average H' values from the Weeks Island stations are somewhat above average for clean estuarine waters. The H' values at West Hackberry increased in the fall due to an increase in species richness. A decrease in the winter values was attributable to both a drop in richness and evenness (Appendix Table 10).

The patchy distribution of M. lateralis was a primary cause for the decrease in evenness. The spring H' value showed an increase which

correlated with an increase in the evenness value. In general, the evenness values were lower at the West Hackberry site than at Weeks Island, indicating a greater faunal patchiness at West Hackberry (Appendix Tables 10, 11, and 12).

Both species evenness and richness values for each station (summed triplicate sample data) are displayed in Appendix Tables 11 and 12. Station to station comparisons of species richness for West Hackberry show high values (over 9.0) for stations 2, 9, 10, and 19--all offshore and farthest away from Calcasieu Pass. Lowest average richness values (below 7.0) were calculated for stations 7, 8, 11, 16, and 17, all inshore stations. On the other hand, species richness values for Weeks Island stations were all over 8.5, with two stations exceeding 10.0. Lowest values were calculated for stations 2 and 18, while highest values were observed for stations 5 and 14. No discernable pattern can be drawn from species richness at Weeks Island, except for its relative uniformity (Appendix Tables 11 and 12).

Values for species evenness indices on a station to station basis are uniform and low at West Hackberry. Half of the stations are characterized by evenness values of 0.51 to 0.55. Three stations (2, 10, 19) range from 0.69 to 0.74, and all are located at the greatest distance from Calcasieu Pass and are offshore. Lowest values (stations 8, 16, 17) are clustered around the planned outfall location. Higher values of species evenness characterize the Weeks Island site. Stations with highest evenness indices (0.72 to 0.74) are stations 2, 6, 14, 16, and 17; while lowest values were calculated for stations 8, 9, and 10, all located close to the planned diffuser site. However, the Weeks Island site is characterized by much higher and more random distribution of evenness values than those for West Hackberry.

Mean numbers of individuals per square meter at West Hackberry site (Appendix Figure 8) and biomass (Appendix Figure 4) generally showed a steady increase from a low during the summer to a high in the spring. This agrees well with data collected at the Bryan Mound brine disposal site off Freeport, Texas (Hann et al. 1979). The monthly sampling there revealed that a population low occurred during the late summer to early fall, followed by a gradual increase through March, and a rapid increase through May. After May, the population decreased precipitously through August (Hann et al. 1979). Numbers of individuals per square meter collected in this study ranged from 1144 to 3080 (11,200 with Mulinia) at West Hackberry--somewhat higher than found in similar studies from the area. Ragan (1975) recorded 860 individuals per square meter from the Louisiana offshore oil port (LOOP) study, 5000 to 7000 individuals per square meter were recorded from the Buccaneer Oil Platform Study (U.S. Department of Commerce, NOAA 1977), and a range of 600 to 4700 individuals per square meter was found at the nearshore site at Bryan Mound (Hann et al. 1979). Preliminary data from the SAI study for the first four months (September through December 1977) showed the mean number of individuals at West Hackberry to be 250 per square meter (U.S. Department of Energy 1978). A different size sieve was used to screen the animals, so numbers are not strictly comparable.

Numbers of individuals per square meter increased at a greater rate than did standing crop. This increase in number over biomass was a result of seasonal increases in the numbers of some smaller sized polychaetes like Mediomastus californiensis and Sabellides oculata (which did not contribute much to the biomass) and seasonal decreases in the numbers of some larger worms such as P. pinnata (Appendix Tables 8 and 13). Weights of some of the more common benthic fauna are displayed in Appendix Table 14. The

presence of large numbers of Cirriformia sp. during the winter and spring and P. pinnata during the summer and fall is important. These soft bodied worms, both of which attain lengths of up to 60 mm, are undoubtedly a vital link in the benthic food chain. A dramatic increase or decrease in their standing crops would cause a change in the amount of energy available to many benthic feeding organisms. Interestingly, the standing crop of soft bodied organisms (total g/m² minus Mulinia g/m²) was relatively stable at the West Hackberry site (Appendix Figure 4). A spring peak in the standing crop is evident from the other sampling periods. This is energy that is available to the nekton and shrimp migrating through the area at this time.

Total numbers of individuals counted at each station (minus the large counts for Mulinia during the winter and spring) were calculated for the four cruises (Appendix Tables 1, 2, and 3), and a 95% confidence interval was calculated and plotted for the mean number at the West Hackberry site (Appendix Figure 9). Stations 6, 7, and 16 fall below this mean, while stations 8, 9, and 18 fall above the mean.

The Bray-Curtis similarity index was calculated to compare the similarity of counts of organisms collected at each station (Appendix Table 15). Station 2, Cruise 1, is the only station that falls outside the normal distribution of sample means for the Bray-Curtis similarity index, indicating that it is least similar to all other stations and may not be a part of the overall West Hackberry benthic assemblage. The sediment analysis for the first cruise showed station 2 to have a higher than average amount of sand (Hausknecht 1980). On the other hand, Bray-Curtis calculations for other seasons at West Hackberry revealed major differences from 1978 summer sampling. The similarity variant for the

fall cruise was station 10 (Appendix Table 15), station 6 for the winter cruise, and station 6 again for the spring cruise (Appendix Table 15). The dominant benthic animals at station 2 were Magelona sp. and P. pinnata which was in reverse order from the rest of the stations for that cruise. The counts of P. pinnata were the lowest of any of the stations sampled that month. The polychaete Lumbrineris tenuis was abundant at this particular station when compared with the other stations. A complete list of taxa numbers by stations for the West Hackberry site is given in Appendix Table 13--for sake of brevity, genera only are given. In only two instances were there more than two species within a genus represented and these (small numbers) were lumped. In essence, the data in Table 13 are the basic numbers underlying all of the statistical calculations.

Weeks Island Site

Species composition at Weeks Island (Appendix Tables 16 and 17) is dominated by crustaceans and polychaetes. The predominant benthic fauna present during the summer were the polychaetes M. californiensis and P. pinnata. In the fall, there was a switch to M. californiensis and Aglaophamus verrilli. During the winter, a large settling of the pelecypod M. lateralis occurred, and the polychaete A. verrilli was still predominant. By spring, M. lateralis was still the most abundant form followed by the polychaete Scolecoplepides viridis (Appendix Table 7)

Although the feeding types at Weeks Island are dominated by deposit and suspension feeders, omnivores and carnivores are well represented. The brittle star M. atra, a scavenger, showed very high numbers of individuals during the summer but not at any other time of the year. This species of brittle star and Luidia clathrata, a starfish, proved extremely abundant (during June 1971) surrounding Shell Platform B some 58 miles du

east of the Weeks Island site after a prolonged (120 day) fire which burned from December 11, 1970 until the end of March 1971 (Coastal Ecosystems Management, Inc., unpublished data file; and Resources Technology Corporation 1972). The predatory gastropods Nassarius acutus and Tectonatica pusilla were seasonally abundant. The predatory nemertean C. lacteus was abundant in the summer when the highest standing crop of soft bodied polychaetes was evident (Appendix Tables 16 and 17).

Other benthic fauna exhibited seasonal changes in numbers and biomass. The anemone Paranthus rapiformis was found almost exclusively during the summer. The caridean Ogyrides limicola was abundant in the summer and fall. The cumacean Diastylis sp. was most common in the summer. Several genera of amphipods were seasonally abundant. Ampelisca sp. was common in summer and fall; Monoculoides sp. was very abundant during spring (Appendix Tables 16 and 17).

Seasonal differences were quite marked at Weeks Island. Numbers of species (Appendix Figure 7), numbers of individuals per square meter (Appendix Figure 10), and biomass or standing crop (Appendix Figure 11), dropped drastically from summer to fall and did not begin to increase until spring. Numbers of individuals per square meter ranged from 660 to 2365 (6185 with Mulinia). Previous studies in this area at the Weeks Island and Chacahoula brine disposal sites recorded mean numbers of 530 and 700 individuals (respectively) per square meter (U.S. Department of Energy 1978). The standing crop found in this study in the fall was only one-fifth of what it was in June. The species diversity decreased from summer through winter as a result of a decrease in species richness (Appendix Table 10). A large drop in diversity in the spring is attributable to the drop in evenness as a result of the patchy distribution

of M. lateralis during that season.

On the 29th of August, the center of tropical storm DEBRA passed the western edge of the West Hackberry site. However, the storm had a definite effect on the Weeks Island site as well. Ten current meters deployed there broke loose from their suspension points and became buried as deep as 3 feet in the bottom and required the use of underwater metal detectors to recover them (U.S. Department of Commerce, NOAA 1979). The complete mixing and reburying of the sediment in which the benthic fauna lives obviously would have a drastic effect on all but the most tolerant of organisms. Those animals generally regarded as more sensitive to poor water quality (e.g., peracarid crustaceans and suspension feeding mollusks) were the most affected, if decreases in population density from a single set of samples taken subsequently can be considered sufficient evidence.

Total numbers of individuals counted at each station (minus the large counts for Mulinia during the winter and spring) were calculated for the four cruises, and a 95% confidence interval was calculated for the mean number at the Weeks Island site (Appendix Figure 12). Stations 8, 9, and 14 fell below this mean, while stations 5, 6, and 18 were above this mean.

The Bray-Curtis similarity index was run on all stations for all seasons in order to compare the similarity of counts of organisms collected at each station. Station 14 (on the sand bar furthest away from the site center) is the only station that falls outside the normal distribution of sample means, indicating that it is not a part of the normal Weeks Island benthic assemblage (Appendix Table 18). The sediment analysis for the first cruise at Weeks Island showed the entire area to be located on silty sand, with the exception of station 14 which was located on an almost pure

sand bottom, further suggesting that station 14 is unique (Hausknecht 1980). The dominant benthic animals present at station 14 were the tube-dwelling polychaete Owenia fusiformis and the brittle star M. atra. The predominant species at the other stations (M. californiensis and P. pinnata) were poorly represented at station 14. Adults of the surf clam, M. lateralis, were not particularly common at this station.

A list of dead shells or parts of shells found in the samples from both sites is given in Appendix Table 19. For the most part, only the rare occurrences added species to the list of live shells from the two areas. Two species, Amygdalum papyria and Haminoea antillarum, are more characteristic of bay areas but appear to be accidentals only and not relicts of previous conditions. All other species are normally found in the nearshore Gulf (1 to 20 meters deep) habitats (Parker 1960). Because so few dead shells, none representing habitats different from the present one, were found, little significance can be placed on dead shell presence or absence. This was not the case in sampling for the SAI study, in that one set of samples (Big Hill site) were taken on exposed Pleistocene clay surfaces which contained shell material quite different from the living assemblage (C.E.M. unpublished data).

Meiofauna

The sandier sediments of Weeks Island supported an overall greater density of meiofauna than at the West Hackberry site (Appendix Tables 2 and 20). Nematodes constituted the predominant taxa at both sites, accounting for over 93% of the animals counted during the fall, winter, and spring. A summer bloom of tintinnids was present at both West Hackberry and Weeks Island (Appendix Table 21). The tremendous numbers of these protozoans skewed population density and diversity levels for

that season at both sites.

Harpacticoid copepods were more numerous at Weeks Island than at West Hackberry, while kinorhynchs were more prevalent at West Hackberry than at Weeks Island (Appendix Table 21). Larval pelecypods were found in the meiofauna in the greatest concentrations during the winter and spring cruises at West Hackberry. This correlates with the very high numbers of juveniles of M. lateralis encountered during the winter and spring at this site. At Weeks Island, the larval pelecypods showed the greatest concentrations in the summer and fall. They were present also during the winter and spring, but in lower numbers.

Lack of large numbers of peracarid crustaceans, common in other habitats sampled for meiobenthos (Parker 1975), suggests that both areas are adverse for normal meiobenthic populations. Studies by other workers in meiobenthos show that when peracarids are absent, predictability of environmental variables is low and ranges of ecological factors are in excess of normal variability for similar habitats (Howard L. Sanders and Frederick Grassle, Woods Hole Oceanographic Institution, personal communication, 1975).

Discussion

A series of comments can be made regarding the aforementioned results of study of the benthic communities at Texoma (West Hackberry) and Capline (Weeks Island) salt brine disposal sites. These comments are based primarily on the evidence produced only during the present investigation, plus some generalizations involving data collected by C.E.M. for SAI prior to starting the present study. The SAI data have not been released for publication, nor have we been able to obtain permission from SAI (who still retains the rights of usage) to publish direct results of these collections.

On the other hand, some generalizations and overall observations could be made regarding similarities and differences between benthic populations and invertebrate distributions as revealed by the C.E.M./SAI studies and those being reported in this study. Likewise, present benthic data have been compared in a general way with data on other trophic levels collected by Energy Resources Company Inc. (Hausknecht 1980) and Texas A&M University at Galveston, Department of Marine Biology (Schwarz et al. 1980).

Comparisons of kinds and numbers of bottom animals between the West Hackberry and Weeks Island sites demonstrate that faunal diversity is lower at West Hackberry than at Weeks Island. This agrees in part with the findings of Landry and Armstrong (1980) for nekton populations and Schwarz et al. (1980) for aerobic bacterial populations in the sediments. This higher diversity for Weeks Island stations is especially true for molluscan and crustacean species, but not necessarily for the predominant forms (the polychaetes) which constitute the most abundant and diverse taxa at both sites. Polychaetes are numerically abundant in the same depths in surrounding waters as revealed by studies relating to benthic communities living near drilling platforms located off Timbalier Bay (Farrell 1974; Fish et al. 1974; and Kritzler 1974). On the other hand, mollusks and crustaceans, so important in similar depths off central and south Texas, are relatively uncommon off southwest Louisiana. Finer sediments occurring close to shore and somewhat unpredictable and lower salinities in the Louisiana region may be a major contributing factor to these regional differences. Higher organic matter content of the sediments off Louisiana as compared to sediments off Texas are suspected as being a factor in influencing benthic population size and composition, although no immediate data for supporting this contention are available

from the lower Texas coast at this time. High organic content of sediments would tend to support higher populations of polychaetes, nematodes, and other small deposit-feeding organisms than high populations of suspension-feeding mollusks and crustaceans, which feed primarily on larger organic matter particles as scavengers, or small living organisms as predators. This premise is partially supported by the fact that total organic carbon levels in sediments off West Hackberry are twice as high as those found off Weeks Island (Hausknecht 1980), and more polychaetes and less crustaceans characterize West Hackberry benthos. Information on higher trophic level interaction was to be dependent upon stomach analysis data supplied by Landry and Armstrong. However, at time of completion of this report those data were not available. Only the fact that ~90 percent of the benthic species are deposit or detritus feeders could be derived from our own results.

Total populations of benthos differ considerably between the two sites, with higher populations characterizing the Weeks Island, also. However, this is in striking contrast to the findings of Landry and Armstrong (1980) who documented much higher nekton populations at the West Hackberry site than at the Weeks Island site. Explanations for this phenomenon centered on the fact that the West Hackberry site is more estuarine in character, acting as a nursery ground for large numbers of juvenile fish and shrimp. On the other hand, the Weeks Island site is further offshore, attracting adults during certain seasons, but offering little habitat preference for these same organisms as juveniles or larva. It is highly possible that the low populations of benthos occurring at both sites when high populations of fish were taken at the same time could be the result of predation. Sciaenid fishes are known to feed mostly on

polychaetes, small crustaceans, and some mollusks in the Mobile Bay-Mississippi Sound area, which has an almost identical benthic community to that found off southern Louisiana (Parker, Westerhaus, and Turgeon 1979; Overstreet and Heard 1978 a and b). According to Landry and Armstrong (1980) sciaenid fishes are the predominant group found at both sites most of the year. Unfortunately, stomach analyses (see Landry and Armstrong 1980) needed to substantiate the predation premise were not available for direct correlation at this writing.

Overall seasonal community composition is partly related to seasonal changes in bottom salinity, temperature, and dissolved oxygen plus some more subtle physical and chemical factors including passage of storms, so far as large-scale mortalities and recruitment are concerned. Both mortality and recruitment are biotic factors, not only controlled by the external environment, but, more importantly, biotic interactions--including nekton predation, niche preference, and food selectivity--not discernible at this investigative level. Certainly, seasonal fluctuations in temperature, and probably salinity, influence reproduction timing and success, since annual settlements of larvae for many species occurring at both sites correlate closely with seasonal temperature changes and to some extent salinity changes. Many biotic interactions, however, cannot be tied directly to environmental changes, and are probably the result of slow evolutionary adjustments of species to other species, especially as to roles as food sources and niche occupiers.

Rapid turnover characterizes fauna (both mega and meiobenthos) of both sites, with apparent attainment of sexual maturity taking place in less than a year for most of the predominant species. Larvae of these species comprising 75 percent of the fauna are produced in late spring to

early fall for some, and only in the late fall for others. These comments are based on general observations of zooplankton and benthic sampling carried out on a monthly basis for SAI. The settlement of many species seems to occur at times that could permit them to complete a reproductive and growth cycle before anoxic conditions occur in late summer. Pelagic larvae can escape the low bottom oxygen conditions for a time, settling to the bottom only when bottom oxygen values have risen to acceptable levels. Annual renewal is characteristic for most of the common benthic invertebrate species along the Gulf coast, although many of these same species may take two to three years to attain sexual maturity in shallow, colder waters of the mid-Atlantic coast (Parker 1975). The rapid cycling of nutrients, low diversity, high populations of predators, and extreme variation of unpredictable environmental factors may account for some tendency towards rapid sexual maturity, even though water temperature is considered the major controlling factor.

The composition of the samples taken at both sites indicate that fauna of both areas are characteristic of northern Gulf of Mexico estuarine and open bay mud-bottom habitats. Both the mollusk and crustacean species found throughout the sites are typical of those found in muddy, low to medium salinity bay centers from Mobile, Alabama, to Aransas Bay, Texas. Many of the same species of polychaetes found at the sites are found also in protected bay centers--supported by our findings in the center of Mobile Bay (Parker et al. 1979). The distribution of many of these species within most Texas and Louisiana bays is not well known, since few studies of polychaete taxonomy have been carried out on worms taken in these bays. Community composition confirms the original premise (derived from the 1977-78 SAI and C.E.M. studies, unpublished data) that the benthic communities of these two sites are almost totally estuarine in character,

reflecting unstable and unpredictable environmental conditions.

Unstable environmental conditions refer to the fact that salinity, temperature, and dissolved oxygen values change constantly with tides, winds, and river discharges. The unstable character of these environmental characteristics are revealed in the representative water column plots from two stations at each site taken from C.E.M. Hydrolab Surveyor casts (Appendix Figures 5 and 6). Note that at least three separate water masses may be present at some stations, and values may range more in a few miles than they do in a season in offshore waters. Predictability is construed as the rhythmicity of change in temperature, salinity, or other water quality parameters. For instance, in an upper estuary, change from low to high salinity is relatively predictable, when river flows are constant and tidal exchanges are regular. Seasonal changes on the continental shelf are predictable, within a few weeks, as to temperature fluctuations. Bottom temperatures and salinity in the deep sea are highly predictable, differing only by minute fractions from century to century. According to Slobodkin and Sanders (1969), diversity is highest in stable and predictable habitats, while lowest diversity occurs under highly unpredictable environmental conditions. Taking this concept one step further, when the aquatic environment is both highly unstable and unpredictable, both diversity and abundance can be very low. A discussion of this hypothesis as applied to Texas coastal benthic communities is given in Parker (1976).

The estuarine characteristics, including the natural variability and unpredictability, of these two sites also are modified by additional stress of yet unknown sources. Lack of certain mollusk species commonly associated with this community elsewhere in the Gulf, and an almost

complete absence of peracarid crustaceans (amphipods, isopods, cumaceans, and certain types of copepods) strongly suggest some environmental stresses could be associated with man. These environmental stresses cannot be isolated at this time as to whether they are natural or man-made. However, natural stress must play a major part in creating low diversity and producing relatively small populations at these sites. Predictability is very low as to shifting abiotic factors; such as, salinity, temperature, waves, and dissolved oxygen. In addition to low predictability, there is a wide variation of abiotic factors characteristic of river-influenced estuaries. The combination (for centuries) of low predictability and high variability of the aquatic environment is selective to the elimination of only a few hardy, rapidly reproducing benthic species.

It is evident that man-made stresses cannot be eliminated as causes for low diversity and abundance as to benthic life in the vicinity of Calcasieu (U.S. Army Engineer District 1979) and Sabine Passes (Parker, et.al. 1975). These data indicate that constant industrial pollution has all but eliminated the benthic infauna at the entrances to these passes and out to 10-meter depths nearby. As these passes are close to the West Hackberry site, their pollutants could reach the areas sampled in this study.

The Weeks Island site may be stressed only by natural perturbations of the Atchafalaya River, which is not nearly as polluted as the west Louisiana passes, but which has a much higher volume of water. The higher diversity and presence of a few species and individuals of peracarid crustaceans support the premise that this area has much less industrial pollution than the West Hackberry site. It also may have a more stable

and predictable environment.

CONCLUSIONS

1. The West Hackberry site is characterized by a less diverse megafauna than Weeks Island in terms of the number of taxa present. In general, there were fewer species and fewer numbers of crustaceans and mollusks taken at West Hackberry than at Weeks Island. The calculated diversity indices were higher at the Weeks Island site than at the West Hackberry site, with the exception of those for the spring cruise.

2. The species composition and numbers of benthic animals from the nearshore Louisiana coast appears to be affected by season, storm surges, and low dissolved oxygen in the bottom water during the summer.

3. The Weeks Island site was affected by the passage of tropical storm DEBRA to a much greater extent than the West Hackberry site.

4. A large area of the nearshore Gulf off the Louisiana coast, especially near Calcasieu Pass, is characterized by critically low bottom dissolved oxygen values during the summer. The very low dissolved oxygen values at West Hackberry may control larval settlement and survival.

5. The benthic communities at both sites have a rapid turnover rate, and most species appear to complete their life cycles in a year or less. Larvae of polychaetes and mollusks settle out in the fall and winter; therefore, they are less subject to the critical environmental conditions (low dissolved oxygen and high temperatures) of summer.

6. No consistent station to station correlations could be found between sediment type and benthic abundance and diversity. This statement is based on calculated coefficients for all stations at each site and

season. As these correlations were statistically nonsignificant, they are not included.

7. Mulinia lateralis and Nassarius acutus are the most abundant mollusks at the West Hackberry site, and, to a lesser extent, off Weeks Island. These two species are often common in estuaries or areas of high river discharge. The numbers of individuals and biomass of M. lateralis were greatest during the winter and spring.

8. As a group, the polychaetes were most important throughout the year in terms of biomass and numbers of individuals. There were seasonal trends in dominance within this group, and there were distinct differences in the polychaete species composition at each site.

9. The types of benthic organisms present and extremes and means of temperature-salinity data indicate that both sites are more characteristic of estuarine habitats than they are of open Gulf waters.

10. Lack of large numbers of peracarid crustaceans in the meiofauna and megafauna suggests that normal environmental conditions at both sites are unpredictable and beyond normal ranges for open ocean conditions.

11. An analysis of species diversity, evenness, and richness for both sites revealed that the central portion of each sampling area is of lower overall quality than the rest of the region. This exercise suggests that the planned location of the diffuser will least affect benthic diversity and abundance.

12. Finally, of the two sites studied on this project, the Texoma (West Hackberry) site is generally poorer in benthic community attributes than the Capline (Weeks Island) site, but this statement may not characterize the situation for other trophic levels.

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APPENDIX

Table 1. Mean and standard deviation of animals per 1/20 m² triplicate grab samples of megafauna at all stations for all seasons.

Station	1978				1979			
	June		November		January		May	
	(\bar{x})	(SD)	(\bar{x})	(SD)	(\bar{x})	(SD)	(\bar{x})	(SD)
WEST HACKBERRY								
2	53 ± 15		58 ± 9		127 ± 10		167 ± 8	
5	57 ± 15		54 ± 13		305 ± 103		327 ± 57	
6	54 ± 2		81 ± 46		53 ± 17		839 ± 246	
7	38 ± 3		60 ± 19		872 ± 192		174 ± 14	
8	62 ± 10		55 ± 6		774 ± 276		395 ± 132	
9	81 ± 13		51 ± 12		94 ± 17		258 ± 70	
10	52 ± 7		52 ± 13		97 ± 20		166 ± 23	
11	54 ± 9		84 ± 20		648 ± 282		180 ± 37	
14	76 ± 3		96 ± 12		366 ± 146		468 ± 37	
16	48 ± 8		71 ± 13		1591 ± 494		374 ± 331	
17	45 ± 8		100 ± 11		994 ± 420		270 ± 103	
18	55 ± 13		85 ± 7		1395 ± 315		428 ± 109	
19	50 ± 5		50 ± 6		127 ± 39		198 ± 67	
WEEKS ISLAND*								
2	108 ± 48		24 ± 6		43 ± 14		767 ± 103	
5	136 ± 35		39 ± 15		64 ± 23		119 ± 36	
6	101 ± 40		54 ± 23		11 ± 5		439 ± 29	
7	67 ± 10		63 ± 18		16 ± 7		150 ± 11	
8	126 ± 48		62 ± 9		43 ± 2		226 ± 58	
9	139 ± 32		28 ± 13		17 ± 14		759 ± 73	
10	135 ± 34		37 ± 11		38 ± 11		306 ± 37	
11	125 ± 6		39 ± 10		23 ± 16		102 ± 21	
14	106 ± 7		36 ± 6		40 ± 10		66 ± 47	
16	108 ± 44		49 ± 14		12 ± 5		161 ± 25	
17	102 ± 35		48 ± 14		39 ± 7		128 ± 40	
18	184 ± 70		33 ± 1		31 ± 3		579 ± 95	
19	140 ± 21		38 ± 10		56 ± 11		319 ± 107	

*The spring cruise to Weeks Island was made in April 1979.

Table 2. Mean and standard deviation of animals per 1/10 cm² cores for triplicate samples of meiofauna (500 μ - 63 μ) at all stations for all seasons.

Station	1978				1979			
	June		November		January		May	
	(\bar{x})	(SD)	(\bar{x})	(SD)	(\bar{x})	(SD)	(\bar{x})	(SD)
WEST HACKBERRY								
2	3546 \pm	1894	1271 \pm	226	1108 \pm	241	126 \pm	44
5	1572 \pm	404	780 \pm	266	562 \pm	248	767 \pm	503
6	1901 \pm	1587	367 \pm	227	301 \pm	179	675 \pm	562
7	959 \pm	313	583 \pm	423	633 \pm	366	199 \pm	30
8	2179 \pm	489	981 \pm	243	754 \pm	184	266 \pm	272
9	921 \pm	798	1073 \pm	1573	900 \pm	356	1333 \pm	188
10	2285 \pm	1481	1595 \pm	1246	970 \pm	367	669 \pm	238
11	805 \pm	694	475 \pm	284	961 \pm	374	315 \pm	154
14	789 \pm	349	586 \pm	403	671 \pm	505	850 \pm	118
16	2696 \pm	788	333 \pm	251	542 \pm	196	306 \pm	109
17	381 \pm	42	631 \pm	479	500 \pm	214	310 \pm	94
18	796 \pm	452	379 \pm	288	812 \pm	209	306 \pm	225
19	1734 \pm	956	271 \pm	73	642 \pm	287	492 \pm	393
WEEKS ISLAND*								
2	2980 \pm	520	590 \pm	561	1320 \pm	640	911 \pm	102
5	2174 \pm	263	382 \pm	390	1162 \pm	248	1681 \pm	496
6	1978 \pm	887	3222 \pm	2959	680 \pm	175	3624 \pm	1367
7	2644 \pm	1382	1996 \pm	584	1623 \pm	159	2402 \pm	413
8	3170 \pm	1848	1503 \pm	1446	1404 \pm	421	2152 \pm	916
9	2863 \pm	1123	209 \pm	145	97 \pm	54	864 \pm	122
10	2163 \pm	473	525 \pm	425	950 \pm	188	910 \pm	536
11	3597 \pm	928	1008 \pm	788	831 \pm	392	1990 \pm	530
14	4062 \pm	1048	2086 \pm	1149	1858 \pm	738	3003 \pm	581
16	3874 \pm	883	695 \pm	366	958 \pm	337	2696 \pm	244
17	3998 \pm	1938	1011 \pm	163	1078 \pm	621	1825 \pm	560
18	2084 \pm	626	448 \pm	240	575 \pm	154	647 \pm	111
19	2137 \pm	1205	435 \pm	252	861 \pm	365	1744 \pm	484

The spring cruise to Weeks Island was made in April 1979.

Table 3. Megafauna and meiofauna total populations per sit by season and average populations by site per station by season.

Season	Total Number per Site	Average Number per Station	Standard Deviations per Site	Mean of Station Standard Deviations	Coefficients of Variation per Site	Overall Coefficients of Variation
WEST HACKBERRY						
MEGAFUNA						
Summer (June)	725	55.77	111	8.54	0.15	
Fall (Nov.)	833	64.08	187	14.38	0.22	
Winter (Jan.)	7,443	572.54	2,331	179.31	0.31	
Spring (May)	4,244	326.46	1,234	94.92	0.29	
All Seasons						0.24
MEIOFAUNA						
Summer (June)	20,564	1,581.85	10,207	785.15	0.50	
Fall (Nov.)	9,325	717.31	5,739	441.46	0.62	
Winter (Jan.)	8,356	642.77	3,726	286.62	0.45	
Spring (May)	6,614	508.77	2,930	225.39	0.44	
All Seasons						0.50
WEEKS ISLAND						
MEGAFUNA						
Summer (June)	1,577	121.31	430	33.08	0.27	
Fall (Nov.)	550	42.30	150	11.54	0.27	
Winter (Jan.)	433	33.31	128	9.85	0.30	
Spring (Apr.)	4,121	317.00	682	52.46	0.17	
All Seasons						0.25
MEIOFAUNA						
Summer (June)	37,706	2,900.46	13,124	1,009.54	0.35	
Fall (Nov.)	14,110	1,085.38	9,468	728.31	0.67	
Winter (Jan.)	13,397	1,030.54	4,492	345.54	0.34	
Spring (Apr.)	23,629	1,817.62	6,462	497.08	0.27	
All Seasons						0.41

Standard deviations from the mean populations by site and by station are averaged as coefficient of variation by site per season, by station per site by season, and by site for year for both components of the population.

Table 4. The t-test values derived from a comparison of means of total megafauna collected in three replicate grab samples per station per season for both the West Hackberry and Weeks Island sites.

	1978		1979	
	Summer	Fall	Winter	Spring
WEST HACKBERRY				
Summer	X	2.24*	3.58*	5.20*
Fall		X	3.48*	4.93*
Winter			X	1.61
Spring				X
WEEKS ISLAND				
Summer	X	9.31*	9.74*	2.85*
Fall		X	1.56	4.02*
Winter			X	4.15*
Spring				X

*Statistically significant difference

t-test assumptions

$\alpha = 0.05$, 2 tailed

$H_0: \mu_1 = \mu_2$

$H_a: \mu_1 \neq \mu_2$

24 degrees of freedom

Table 5. The F test values derived from comparison of variances of total megafauna collected in three replicate grab samples per station per season for both the West Hackberry and Weeks Island sites.

	1978		1979	
	Summer	Fall	Winter	Spring
WEST HACKBERRY				
Summer	X	2.38	1996.81*	257.83*
Fall		X	838.85*	108.31*
Winter			X	7.74*
Spring				X
WEEKS ISLAND				
Summer	X	5.15*	2.82	77.19*
Fall		X	1.83	397.84*
Winter			X	217.86*
Spring				X

*Statistically significant difference

F test assumptions

$\alpha = 0.05$, 2 tailed

$$H_0: \sigma_1^2 = \sigma_2^2$$

$$H_a: \sigma_1^2 \neq \sigma_2^2$$

degrees of freedom: 12 and 12

Table 6. Percent composition of the major taxa of megafauna at each site.

Taxa	West Hackberry (%)	Weeks Island (%)
Polychaetes	44.3	33.1
Crustaceans	21.6	36.5
Mollusks	17.0	15.9
Other	17.1	14.5
Total number of taxa	89	146

Table 7. Percent composition of dominant megabenthic species (>0.5 mm) by season.

West Hackberry		Weeks Island	
Species	% Composition	Species	% Composition
Summer (June)			
<u>Paraprionospio pinnata</u>	54.48	<u>Mediomastus californiensis</u>	20.85
<u>Magelona</u> sp.	14.71	<u>P. pinnata</u>	16.77
<u>Cossura delta</u>	6.94	<u>Mulinia lateralis</u> (pelecypod)	7.68
<u>Lumbrineris tenuis</u>	3.49	<u>Magelona</u> sp.	7.11
Total	79.62	<u>Owenia fusiformis</u>	5.77
		<u>Paranthus rapiformis</u> (actinarian)	5.77
		Total	63.95
Fall (November)			
<u>P. pinnata</u>	47.53	<u>M. californiensis</u>	28.71
<u>Sigambra tentaculata</u>	12.71	<u>Aglaophamus verrilli</u>	19.56
<u>Glycera dibranchiata</u>	7.17	<u>Haploscoloplos fragilis</u>	9.51
<u>Magelona</u> sp.	4.53	<u>P. pinnata</u>	5.09
<u>C. delta</u>	3.53	<u>Ogyrides limicola</u> (caridean)	4.24
Total	75.47	<u>Nassarius acutus</u> (gastropod)	4.06
		Total	71.17
Winter (January)			
<u>M. lateralis</u> (pelecypod)	79.00	<u>M. lateralis</u> (pelecypod)	18.08
<u>Cirriiformia</u> sp.	7.14	<u>A. verrilli</u>	15.77
<u>M. californiensis</u>	2.85	<u>M. californiensis</u>	15.00
<u>Magelona</u> sp.	2.49	<u>Scolecopides viridis</u>	10.76
Total	91.48	<u>H. fragilis</u>	8.46
		Total	68.07

Table 7. (conclud d)

West Hackberry		Weeks Island	
Species	% Compo- sition	Species	% Compo- sition
Spring (May)			
<u>M. lateralis</u> (pelecypod)	51.63	<u>M. lateralis</u> (pelecypod)	67.23
<u>Cirriformia</u> sp.	15.92	<u>S. viridis</u>	10.52
<u>Sabellides oculata</u>	8.53	<u>M. californiensis</u>	8.28
<u>M. californiensis</u>	5.97	<u>Monoculoides</u> sp. (amphipod)	3.19
<u>Magelona</u> sp.	3.87	Total	89.22
Total	85.92		

*All species are polychaetes unless indicated.

Table 8. Seasonal counts of *m gafauna* by sp cies at the W st Hackberry site.

Taxa	Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
PHYLUM CNIDARIA					
Class Hydrozoa	...	...	...	2	2
Class Anthozoa					
Order Actiniaria					
<u>Paranthus rapiformis</u>	9	6	7	3	25
<u>Bunodactis texaensis</u>	...	...	...	2	2
Unidentified anthozoan	1	...	1	...	2
PHYLUM PLATYHELMINTHES					
Order Polycladida					
<u>Stylochus ellipticus</u>	5	...	12	14	31
Unidentified Polycladida	...	...	1	...	1
PHYLUM NEMERTINA					
<u>Cerebratulus lacteus</u>	15	79	66	236	396
Unidentified nemertean	...	...	2	...	2
PHYLUM ASCHELMINTHES					
Class Nematoda	36	11	13	8	68
PHYLUM ANNELIDA					
Class Polychaeta					
Family Polynoidae					
<u>Harmothoe aculeata</u>	...	4	3	4	11
<u>Lepidasthenia varia</u>	...	19	4	...	23
<u>Lepidonotus squamatus</u>	2	...	...	...	2
Family Sigalionidae					
<u>Stenelais boa</u>	...	13	6	1	20
Family Chrysopetalidae					
<u>Paleanotus heteroseta</u>	3	3	1	1	8

Table 8. (continued)

Taxa	Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
Family Amphinomidae					
<u>Linopherus ambigua</u>	...	68	181	118	367
Family Phyllodocidae					
<u>Phyllodoce arenae</u>	1	5	...	2	8
<u>Phyllodoce mucosa</u>	...	...	...	1	1
Family Pilargidae					
<u>Ancistrosyllis papillosa</u>	54	16	11	52	133
<u>Sigambra tentaculata</u>	43	342	140	395	920
Family Syllidae					
<u>Eusyllis</u> sp.	2	43	27	52	124
Family Nereidae					
<u>Neanthes succinea</u>	...	22	12	5	39
Family Glyceridae					
<u>Glycera capitata</u>	...	...	...	3	3
<u>Glycera dibranchiata</u>	19	193	31	103	346
Family Onuphidae					
<u>Diopatria cuprea</u>	21	15	30	22	88
<u>Onuphis eremita</u>	...	...	2	...	2
<u>Spiochaetopterus oculatus</u>	...	...	1	6	7
Family Lumbrineridae					
<u>Lumbrineris acuta</u>	...	...	5	...	5
<u>Lumbrineris tenuis</u>	76	43	27	72	218
<u>Ninoe nigripes</u>	23	2	3	15	43
Family Orbiniidae					
<u>Haploscoloplos fragilis</u>	2	...	...	...	2
Family Spionidae					
<u>Paraprionospio pinnata</u>	1185	1279	316	134	2914
<u>Prionospio cirrifera</u>	...	...	22	74	96

Table 8. (continued)

Taxa	Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
Family Magelonidae					
<u>Magelona</u> sp. #1	320	122	557	492	1491
<u>Magelona</u> sp. #2	2	2	2	1	7
Family Chaetopteridae					
<u>Chaetopterus variopedatus</u>	...	...	...	1	1
Family Cirratulidae					
<u>Cirriformia</u> sp.	34	12	1596	2024	3666
Family Opheliidae					
<u>Ammotrypane aulogaster</u>	...	...	3	...	3
Family Capitellidae					
<u>Mediomastus californiensis</u>	21	79	637	759	1496
<u>Notomastus</u> sp.	...	...	1	...	1
Family Maldanidae					
<u>Branchiosyllis americana</u>	...	1	...	...	1
<u>Clymenella torquata</u>	48	2	1	...	51
<u>Maldane sarsi</u>	...	...	...	12	12
<u>Maldanopsis elongata</u>	...	...	14	...	14
Family Oweniidae					
<u>Myriowenia</u> sp.	5	...	3	1	9
<u>Owenia fusiformis</u>	14	36	19	10	79
Family Ampharetidae					
<u>Ampharete</u> sp.	2	...	...	...	2
<u>Sabellides oculata</u>	...	42	472	1085	1599
Family Cossuridae					
<u>Cossura delta</u>	151	95	262	266	774
PHYLUM MOLLUSCA					
Class Gastropoda					
Subclass Opisthobranchia					
<u>Coryphella pellucida</u>	...	...	3	...	3

Table 8. (continued)

Taxa	Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
<u>Polinices duplicatus</u>	...	...	1	2	10
<u>Epitonium lamellosum</u>	...	...	...	1	1
<u>Nassarius acutus</u>	1	...	2	2	5
<u>Vitrinella floridana</u>	...	...	1	2	3
Class Pelecypoda					
<u>Mulinia lateralis</u>	35	17	17,650	6,566	24,268
<u>Tellina versicolor</u>	1	1	3	...	5
<u>Nuculana concentrica</u>	2	...	...	...	2
<u>Abra lioica</u>	1	...	...	...	1
<u>Abra aequalis</u>	...	...	...	1	1
<u>Anadara ovalis</u>	...	3	...	...	3
<u>Callocardia texasiana</u>	...	1	...	...	1
<u>Pandora trilineata</u>	...	1	...	...	1
<u>Sinum perspectivum</u>	...	...	1	...	1
<u>Ensis minor</u>	...	...	1	...	1
PHYLUM ARTHROPODA					
Class Crustacea					
Subclass Copepoda					
<u>Labidocera</u> sp.	1	3	3	...	7
Subclass Cirripidea					
<u>Balanus amphitrite niveus</u>	...	...	...	28	28
Subclass Malacostraca					
Superorder Hoplocarida					
Order Stomatopoda					
<u>Lysiosquilla empusa</u>	...	1	...	...	1
Superorder Peracarida					
Order Cumacea					
<u>Diastylis</u> sp.	...	3	17	13	33
Order Amphipoda					
<u>Ampelisca</u> sp.	1	4	7	54	66

Table 8. (continued)

Taxa	Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
<u>Listriella</u> sp.	...	...	2	...	2
<u>Corophium</u> sp.	...	...	2	1	3
Superorder Eucarida					
Order Decapoda					
Section Penaeidea					
<u>Penaeus setiferus</u>	2	1	6	...	9
Section Caridea					
<u>Ogyrides limicola</u>	2	12	1	...	15
Section Macrura					
<u>Callinassa latispina</u>	...	1	...	1	2
Section Anomura					
Family Paguridae -juvenile	1	...	...	...	1
<u>Pagurus longicarpus</u>	...	...	1	...	1
Family Porcellanidae					
<u>Polyonyx gibbesi</u>	...	...	...	1	1
Section Brachyura -larvae	14	2	...	2	18
Family Portunidae					
<u>Portunus gibbesii</u>	...	2	...	...	2
Family Pinnotheridae -juvenile	5	...	14	...	19
<u>Pinnixa chaetopterana</u>	...	22	...	...	22
<u>Pinnixa sayana</u>	...	...	5	3	8
Family Leucosiidae					
<u>Persephona mediterranea</u>	2	1	...	...	3
PHYLUM SIPUNCULIDA	...	1	2	...	3
PHYLUM ECHIURIDA	...	...	2	...	2

Table 8. (concluded)

Taxa	Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
PHYLUM ECTOPROCTA					
<u>Electra hastingsae</u> cf	...	1	...	...	1
PHYLUM ECHINODERMATA					
Subclass Ophiuroidea					
<u>Micropholis atra</u>	2	42	20	17	81
Class Holothuroidea	11	4	98	37	150
PHYLUM HEMICHORDATA					
<u>Balanoglossus</u> sp.	...	14	9	2	25
PHYLUM CHORDATA					
<u>Myrophis punctatus</u>	...	...	...	1	1
Total number of species	41	48	60	52	89
Total Individuals	2,175	2,691	22,342	12,717	39,925

Table 9. Average surface and bottom temperature, salinity, and dissolved oxygen values (mean 13 stations \pm standard deviation).

	West Hackberry			Weeks Island		
	Temperature (°C)	Salinity (°/oo)	Dissolved Oxygen (ppm)	Temperature (°C)	Salinity (°/oo)	Dissolved Oxygen (ppm)
Summer (June 1978)						
Top	29.3 \pm 0.4	21.3 \pm 0.9	7.4 \pm 0.6	30.8 \pm 1.0	17.9 \pm 1.9	7.7 \pm 0.3
Bottom	27.2 \pm 0.6	25.3 \pm 1.8	0.6 \pm 1.5	28.4 \pm 0.5	29.3 \pm 2.0	2.7 \pm 0.6
Fall (November 1978)						
Top	25.7 \pm 1.0	25.5 \pm 1.4	7.7 \pm 0.6	21.7 \pm 0.5	27.6 \pm 1.1	8.4 \pm 0.2
Bottom	25.9 \pm 1.0	27.3 \pm 1.1	4.8 \pm 1.3	22.1 \pm 0.3	28.2 \pm 1.0	7.3 \pm 0.4
Winter (January 1979)						
Top	9.9 \pm 0.6	24.9 \pm 1.0	9.8 \pm 1.0	10.4 \pm 0.4	21.8 \pm 1.1	10.2 \pm 1.3
Bottom	10.6 \pm 0.6	25.4 \pm 0.7	6.5 \pm 1.6	13.4 \pm 1.1	29.6 \pm 1.3	6.9 \pm 1.5
Spring (May 1979)						
Top	23.9 \pm 0.3	16.2 \pm 1.0	7.5 \pm 1.0	23.0 \pm 0.4	16.6 \pm 0.2	7.5 \pm 0.9
Bottom	23.5 \pm 0.2	18.8 \pm 1.5	5.2 \pm 0.9	23.1 \pm 0.4	17.1 \pm 0.9	5.9 \pm 1.6

Table 10. Species diversity, richness, and evenness of megafauna, by site and season (mean \pm standard deviation).

Season	Diversity Index (H')	Species Richness (SR)	Species Evenness (J')
Weeks Island			
Summer (June)	1.06 \pm 0.10	12.08 \pm 1.35	0.70 \pm 0.06
Fall (November)	0.94 \pm 0.14	9.58 \pm 1.63	0.71 \pm 0.07
Winter (January)	0.91 \pm 0.08	7.64 \pm 1.48	0.77 \pm 0.07
Spring (May)	0.62 \pm 0.30	8.49 \pm 2.14	0.44 \pm 0.20
West Hackberry			
Summer (June)	0.72 \pm 0.12	6.76 \pm 1.14	0.60 \pm 0.09
Fall (November)	0.87 \pm 0.20	8.87 \pm 1.71	0.65 \pm 0.12
Winter (January)	0.64 \pm 0.37	7.78 \pm 2.65	0.46 \pm 0.26
Spring (May)	0.72 \pm 0.21	7.55 \pm 1.32	0.53 \pm 0.15

Table 11. Calculations of various statistical indices by stations for all seasons for West Hackberry species data, based on sums of triplicate grabs per station, including Mulinia lateralis counts.

Season	Station												
	2	5	6	7	8	9	10	11	14	16	17	18	19
SHANNON-WEAVER DIVERSITY INDEX													
Summer 1978	0.92	0.70	0.74	0.79	0.57	0.63	0.81	0.63	0.86	0.76	0.49	0.64	0.84
Fall 1978	0.93	0.84	0.51	0.74	0.82	1.09	1.14	0.62	0.96	0.75	0.70	1.04	1.12
Winter 1979	1.07	0.61	1.13	0.26	0.32	1.11	1.09	0.47	0.57	0.20	0.26	0.33	0.91
Spring 1979	0.78	0.74	0.30	0.86	0.72	0.96	0.97	0.87	0.43	0.48	0.64	0.69	0.91
Average	0.92	0.73	0.67	0.66	0.61	0.95	1.00	0.65	0.71	0.55	0.52	0.68	0.95
SPECIES RICHNESS													
Summer 1978	6.36	7.17	8.14	6.82	5.28	7.55	5.93	5.89	8.49	7.87	4.69	6.32	7.34
Fall 1978	8.92	9.49	6.71	7.99	8.13	10.06	10.47	7.50	10.98	6.44	6.86	11.23	10.56
Winter 1979	11.63	7.77	7.71	5.26	6.54	11.43	12.18	6.69	6.25	4.62	5.47	5.52	10.07
Spring 1979	9.27	7.35	5.59	7.36	6.83	9.36	9.27	6.22	6.99	6.23	8.60	6.43	8.65
Average	9.05	7.95	7.04	6.86	6.70	9.60	9.46	6.58	8.18	6.29	6.41	7.38	9.16
SPECIES EVENNESS													
Summer 1978	0.78	0.57	0.58	0.67	0.51	0.49	0.70	0.55	0.65	0.61	0.47	0.54	0.68
Fall 1978	0.70	0.63	0.41	0.58	0.64	0.80	0.83	0.48	0.66	0.62	0.56	0.72	0.81
Winter 1979	0.72	0.44	0.90	0.20	0.23	0.76	0.73	0.35	0.44	0.16	0.20	0.25	0.64
Spring 1979	0.55	0.54	0.23	0.65	0.54	0.66	0.69	0.69	0.32	0.37	0.45	0.52	0.65
Average	0.69	0.55	0.53	0.53	0.48	0.68	0.74	0.52	0.52	0.43	0.42	0.51	0.70

Table 12. Calculations of various statistical indices by stations for all seasons for Weeks Island species data, based on sums of triplicate grabs per station, including Mulinia lateralis counts.

Season	Station												
	2	5	6	7	8	9	10	11	14	16	17	18	19
SHANNON-WEAVER DIVERSITY INDEX													
Summer 1978	0.91	1.20	1.16	1.04	0.95	1.12	1.11	0.95	1.00	1.21	0.92	1.12	1.05
Fall 1978	0.82	1.09	1.06	0.86	1.00	0.84	0.67	0.74	1.02	0.99	1.11	0.94	1.06
Winter 1979	1.01	0.81	1.02	0.90	0.84	0.80	0.92	0.89	0.95	0.82	1.05	0.95	0.89
Spring 1979	0.35	0.83	0.63	1.01	0.43	0.70	0.42	0.88	1.00	0.82	0.93	0.24	0.35
Average	0.77	0.98	0.97	0.95	0.81	0.87	0.53	0.87	0.99	0.96	1.00	0.81	0.84
SPECIES RICHNESS													
Summer 1978	11.16	13.41	13.29	12.17	11.63	12.98	11.50	13.21	10.00	11.95	9.26	13.49	12.96
Fall 1978	6.98	11.60	10.85	8.78	10.12	8.86	7.84	6.76	10.35	10.63	11.58	9.52	10.70
Winter 1979	9.49	7.45	7.97	7.10	6.64	6.41	9.25	5.96	9.62	5.10	9.65	7.11	7.64
Spring 1979	6.25	10.57	7.05	11.30	7.42	8.04	7.43	10.45	10.46	11.17	8.90	4.63	6.71
Average	8.47	10.76	9.79	9.84	8.95	9.07	9.00	9.10	10.11	9.71	9.85	8.69	9.50
SPECIES EVENNESS													
Summer 1978	0.62	0.77	0.76	0.71	0.64	0.73	0.74	0.62	0.71	0.81	0.67	0.71	0.68
Fall 1978	0.72	0.78	0.76	0.65	0.72	0.67	0.54	0.63	0.76	0.72	0.78	0.72	0.78
Winter 1979	0.76	0.65	0.92	0.81	0.71	0.74	0.71	0.82	0.72	0.86	0.79	0.81	0.71
Spring 1979	0.26	0.57	0.46	0.68	0.32	0.14	0.31	0.61	0.72	0.55	0.67	0.20	0.26
Average	0.72	0.69	0.73	0.71	0.60	0.57	0.58	0.67	0.73	0.74	0.73	0.61	0.61

Table 13. Summation of benthic megafauna counts of animals taken at West Hackberry site (Texoma).. Counts are of individuals taken in all three grabs combined.

Genus	Station														Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19			
Cruise 1																
POLYCHAETA																
Lepidonotus	...	...	...	...	...	...	1	...	...	...	...	1	...	2	0.09
Paleanotus	2	...	...	...	...	1	...	...	...	...	...	...	...	3	0.14
Phyllodoce	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.05
Ancistrosyllis	11	3	2	6	3	9	4	...	3	4	1	4	4	54	2.48	
Sigambra	6	1	4	5	6	7	4	2	4	1	...	3	...	43	1.98	
Eusyllis	...	...	...	...	...	...	...	...	1	...	...	...	1	2	0.09
Glycera	...	3	5	1	4	1	...	1	...	2	2	...	...	19	0.87
Diopatra	...	1	4	3	3	1	...	1	...	2	3	1	2	21	0.97	
Lumbrineris	23	13	2	1	2	8	6	1	7	3	...	3	7	76	3.49	
Ninoe	1	2	...	...	2	5	...	...	2	2	...	6	3	23	1.06
Haploscoloplos	...	1	...	...	...	...	...	...	...	1	...	...	...	2	0.09
Paraprionospio	37	91	98	56	125	164	58	85	133	77	98	93	70	1185	54.48	
Magelona	40	28	6	19	22	12	43	41	19	21	17	33	21	322	14.80	
Cirriformia	...	...	5	4	7	...	...	3	2	7	5	1	...	34	1.56
Mediomastus	1	1	6	5	...	...	...	...	5	2	...	...	1	21	0.97
Clymenella	7	1	...	...	1	6	12	...	10	2	...	1	8	48	2.21
Myriowenia	2	...	...	...	...	3	...	...	...	...	...	...	...	5	0.23
Owenia	3	1	1	...	1	...	1	...	5	1	...	...	1	14	0.64
Ampharete	1	...	1	...	...	...	...	...	...	...	...	...	...	2	0.09
Cossura	16	18	10	5	9	11	13	12	15	13	3	14	12	151	6.94	
PELECYPODA																
Mulinia	...	...	10	4	...	1	...	8	...	...	...	1	11	35	1.61
Tellina	...	1	...	...	...	...	...	...	...	...	...	...	...	1	0.05
Nuculana	1	...	...	...	...	...	...	...	...	...	...	...	1	2	0.09
Abra	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.05

Table 13. (continued)

Genus	Station													Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19		
GASTROPODA															
Nassarius	...	...	1	...	...	...	...	...	...	...	...	...	...	1	0.05
ECHINODERMATA															
Micropholis	...	...	...	...	...	...	2	...	...	...	...	...	...	2	0.09
Holothuroidea	...	...	5	1	2	...	...	...	...	1	2	...	...	11	0.51
NEMATODA	8	3	...	...	...	7	5	...	4	4	1	...	4	36	1.66
CRUSTACEA															
Labidocera	...	...	...	...	...	...	...	...	...	...	...	...	1	1	0.05
Ampelisca	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.05
Penaeus	...	...	...	...	...	...	...	...	2	...	...	...	...	2	0.09
Ogyrides	...	...	...	...	...	...	...	...	2	...	...	...	...	2	0.09
Paguridae	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.05
Brachyura	...	1	1	...	...	2	...	1	2	1	2	1	3	14	0.64
Pinnotheridae	...	...	...	1	...	1	2	...	...	...	...	...	1	5	0.23
Persephona	...	...	...	...	...	...	...	2	...	...	...	...	...	2	0.09
CNIDARIA															
Paranthus	...	1	1	...	...	2	4	...	...	...	...	1	...	9	0.41
Anthozoan	...	...	...	...	...	...	...	1	...	...	...	...	...	1	0.05
PLATYHELMINTHES															
Stylochus	...	...	...	...	...	...	...	1	2	...	1	1	...	5	0.23
NEMERTINA															
Cerebratulus	...	...	1	2	...	1	1	2	6	1	1	...	...	15	0.69

Table 13. (continued)

Genus	Station													Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19		
Cruise 2															
POLYCHAETA															
Harmothoe	...	...	...	...	...	...	...	...	...	...	...	...	4	4	0.15
Lepidasthenia	1	...	...	...	...	11	5	1	...	...	...	1	...	19	0.71
Sthenelais	1	3	...	...	3	...	...	...	...	...	...	2	4	13	0.48
Paleanotus	...	...	...	...	...	2	...	...	1	...	...	...	...	3	0.11
Linopherus	...	...	1	...	...	1	15	3	13	1	7	25	2	68	2.53
Phyllodoce	...	...	...	1	...	2	...	...	...	...	...	1	1	5	0.19
Ancistrosyllis	1	1	...	3	1	...	...	2	4	...	...	4	...	16	0.59
Sigambra	24	41	23	15	33	25	18	22	23	33	28	38	19	342	12.71
Eusyllis	2	3	2	2	3	2	5	2	4	5	1	6	6	43	1.60
Neanthes	1	1	...	1	2	2	3	1	5	1	3	1	1	22	0.82
Glycera	10	6	23	14	20	15	14	15	21	15	17	15	8	193	7.17
Diopatra	...	1	2	...	...	1	1	3	1	...	3	2	1	15	0.56
Lumbrineris	8	4	2	1	4	3	1	1	1	6	3	4	5	43	1.60
Ninoe	...	...	...	...	1	...	...	...	1	...	...	...	...	2	0.07
Paraprionospio	74	71	171	103	71	39	37	166	128	112	182	80	45	1279	47.53
Magelona	12	5	3	14	6	9	10	9	12	7	6	22	9	124	4.59
Cirriformia	1	3	1	2	1	1	...	...	1	1	...	1	...	12	0.44
Mediomastus	5	1	1	1	...	4	4	1	25	6	6	19	6	79	2.94
Branchiosyllis	...	...	...	...	...	...	...	...	...	...	...	1	...	1	0.04
Clymenella	...	...	...	...	...	...	2	...	...	...	...	1	...	2	0.07
Owenia	8	1	...	...	...	3	14	...	6	...	...	2	2	36	1.34
Sabellides	...	1	1	2	...	...	...	5	3	4	17	1	8	42	1.56
Cossura	6	4	5	6	9	2	5	9	11	11	8	10	9	95	3.53
PELECYPODA															
Mulinia	...	2	...	3	2	...	1	2	1	...	4	2	...	17	0.63
Tellina	...	...	...	1	...	...	...	...	...	...	...	...	...	1	0.04
Anadara	...	...	...	...	...	...	1	...	1	...	1	...	...	3	0.11
Callocardia	...	...	...	...	1	...	...	...	...	...	...	...	...	1	0.04
Pandora	...	...	...	...	1	...	...	...	...	...	...	...	...	1	0.04

Table 13. (continued)

Genus	Station														Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19			
ECHINODERMATA																
Micropholis	3	3	1	2	1	9	9	...	6	2	...	1	5	42	1.56	
Holothuroidea	...	...	1	...	...	...	1	...	...	...	...	2	...	4	0.15
NEMATODA																
	1	...	...	...	1	1	2	...	2	...	2	2	...	11	0.41
CRUSTACEA																
Labidocera	...	1	...	...	...	...	...	1	...	...	...	...	1	3	0.11
Lysiosquilla	...	...	...	...	...	...	...	...	...	...	...	...	1	1	0.04
Diastylis	...	...	1	...	...	...	...	1	1	...	...	...	...	3	0.11
Ampelisca	3	...	...	...	...	...	...	...	1	...	...	...	...	4	0.15
Penaeus	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.04
Ogyrides	4	...	...	1	...	2	1	...	4	...	...	...	...	12	0.44
Callianassa	...	...	...	...	...	...	...	...	...	...	...	...	1	1	0.04
Brachyura	...	1	...	...	...	1	...	...	...	...	...	...	...	2	0.07
Portunus	...	...	...	...	...	...	...	1	...	...	1	...	...	2	0.07
Pinnixa	3	1	1	...	...	7	3	...	...	1	2	1	3	22	0.82
Persephona	...	...	...	...	...	...	1	...	...	...	...	...	...	1	0.04
SIPUNCULIDA																
	...	...	...	...	...	...	...	...	...	...	...	1	...	1	0.04
ECTOPROCTA																
Electra	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.04
CNIDARIA																
Paranthus	...	2	...	...	...	...	...	...	2	1	...	...	1	6	0.22
NEMERTINA																
Cerebratulus	6	7	3	7	4	11	2	6	8	7	9	5	4	79	2.94	
HEMICHORDATA																
Balanoglossus	1	...	...	...	...	1	3	...	...	...	...	4	5	14	0.52

Table 13. (continued)

Genus	Station													Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19		
Cruise 3															
POLYCHAETA															
Harmothoe	...	...	...	...	...	2	...	...	...	...	...	...	1	3	0.01
Lepidasthenia	...	...	...	...	...	...	3	1	...	...	...	...	...	4	0.02
Sthenelais	...	...	...	...	1	2	1	...	...	...	...	...	2	6	0.03
Paleanotus	...	...	...	...	...	...	1	...	...	...	...	...	...	1	0.00
Linopherus	...	1	27	2	1	7	71	16	1	...	27	28	...	181	0.81
Ancistrosyllis	4	1	...	...	...	1	2	1	...	1	...	...	1	11	0.05
Sigambra	8	11	8	11	9	11	3	9	12	18	13	13	14	140	0.63
Eusyllis	1	1	2	1	2	4	...	1	3	1	3	4	4	27	0.12
Neanthes	...	1	...	1	...	2	2	1	3	1	...	...	1	12	0.05
Glycera	1	5	3	1	1	2	3	4	3	5	2	1	...	31	0.14
Diopatra	1	...	1	3	9	2	...	5	3	...	1	4	1	30	0.13
Onuphis	...	2	...	...	...	...	...	...	...	...	...	...	...	2	0.01
Spiochaetopterus	...	...	...	...	...	...	1	...	...	...	...	...	...	1	0.00
Lumbrineris	11	3	1	3	1	2	3	1	...	...	2	1	4	32	0.14
Ninoe	1	...	...	...	...	1	...	...	...	...	...	...	1	3	0.01
Paraprionospio	19	17	5	53	21	18	12	40	37	37	13	35	9	316	1.41
Prionospio	7	4	...	...	...	...	1	2	4	...	...	1	3	22	0.10
Magelona	66	48	16	16	57	55	52	41	62	16	26	44	60	559	2.50
Cirriiformia	120	137	29	42	121	35	18	182	109	129	84	525	65	1596	7.14
Notomastus	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.00
Clymenella	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.00
Maldanopsis	12	1	...	...	...	1	...	...	...	...	...	...	...	14	0.06
Myriowenia	1	...	...	...	...	...	1	...	...	...	...	...	1	3	0.01
Owenia	11	...	...	...	...	...	7	...	...	...	...	...	1	19	0.08
Sabellides	17	23	1	35	61	18	10	47	24	69	81	63	23	472	2.11
Cossura	18	12	16	46	19	20	23	16	26	26	15	15	10	262	1.17
Mediomastus	37	67	9	26	30	44	46	118	82	64	24	50	40	637	2.85
Ammotrypane	...	...	...	...	...	...	2	...	...	...	...	...	1	3	0.01

Table 13. (continued)

Genus	Station													Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19		
PELECYPODA															
Mulinia	1	570	29	2343	1971	33	8	1443	714	4368	2655	3380	135	17,650	79.00
Tellina	...	...	...	...	...	...	3	...	...	...	...	...	...	3	0.01
Sinum	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.00
Ensis	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.00
GASTROPODA															
Coryphella	...	...	...	...	...	...	...	...	...	...	3	...	...	3	0.01
Polinices	...	...	...	...	...	...	...	...	...	1	...	...	...	1	0.00
Nassarius	...	...	...	1	1	...	...	...	...	...	...	...	...	2	0.01
Vitrinella	...	...	...	...	...	...	...	...	...	...	...	...	1	1	0.00
ECHINODERMATA															
Micropholis	3	...	...	...	3	4	3	2	...	1	1	3	...	20	0.09
Holothuroidea	...	1	6	34	2	...	...	...	4	31	20	...	...	98	0.44
NEMATODA	8	3	...	...	...	1	1	...	...	...	...	...	...	13	0.06
CRUSTACEA															
Labidocera	3	...	...	...	...	...	...	...	...	...	...	...	...	3	0.01
Diastylis	1	1	...	6	2	...	...	3	...	1	1	2	...	17	0.08
Ampelisca	2	...	...	...	1	...	3	...	...	...	...	...	1	7	0.03
Listriella	...	...	...	...	2	...	...	...	...	...	...	...	...	2	0.01
Corophium	...	1	1	...	...	...	...	...	...	...	...	...	...	2	0.01
Penaeus	1	...	...	...	...	...	1	1	...	...	1	1	1	6	0.03
Ogyride	...	...	...	...	...	...	1	...	...	...	...	...	...	1	0.00
Pagurus	...	...	...	...	...	...	...	...	...	...	...	1	...	1	0.00
Pinnotheridae	...	...	...	1	...	6	3	...	1	...	...	1	2	14	0.06
Pinnixa	5	...	...	...	...	...	...	...	...	...	...	...	...	5	0.02
SIPUNCULIDA	2	...	...	...	...	...	...	...	...	...	...	...	...	2	0.01
ECHIURIDA	2	...	...	...	...	...	...	...	...	...	...	...	...	2	0.01
CNIDARIA															
Paranthus	2	...	1	...	1	1	...	...	...	...	...	...	2	7	0.03
Anthozoan	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.00

Table 13. (continued)

Genus	Station														Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19			
PLATYHELMINTHES																
Stylochus	1	1	...	...	4	...	...	1	...	1	1	3	...	12	0.05
Polycladida	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.00
NEMERTINA																
Cerebratulus	14	4	4	4	2	4	1	7	7	4	8	5	2	66	0.03	
Nemertea	...	...	1	...	...	...	...	...	1	...	...	...	...	2	0.01
HEMICHORDATA																
Balanoglossus	...	1	...	...	...	2	4	1	...	...	...	...	1	9	0.04
Cruise 4																
POLYCHAETA																
Harmothoe	...	1	...	...	...	1	2	...	...	...	...	...	...	4	0.03
Sthenelais	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.01
Paleanotus	1	...	...	...	...	...	...	...	...	...	...	...	...	1	0.01
Linopherus	6	2	21	1	13	...	17	21	6	1	9	21	...	118	0.93	
Phyllodoce	...	...	...	...	...	...	...	...	...	...	1	1	1	3	0.03
Ancistrosyllis	4	5	4	3	3	8	9	7	1	1	...	1	6	52	0.41	
Sigambra	19	34	31	39	40	9	11	43	40	33	45	24	27	395	3.11	
Eusyllis	4	7	1	4	7	5	1	3	4	3	...	3	10	52	0.41	
Neanthes	1	...	...	...	...	1	1	1	...	...	...	...	1	5	0.04
Glycera	8	5	8	6	4	13	6	1	18	6	9	11	11	106	0.83	
Diopatra	1	1	...	1	6	1	...	...	2	1	3	3	3	22	0.17
Spiochaetopterus	...	...	...	...	1	...	1	...	...	...	1	1	2	6	0.05
Lumbrineris	13	7	3	1	4	13	6	2	2	1	3	5	12	72	0.57	
Ninoe	6	3	...	1	...	1	...	...	...	...	...	2	2	15	0.12
Paraprionospio	11	11	7	16	5	14	13	6	16	7	12	8	8	134	1.05	
Prionospio	2	7	8	1	7	25	4	...	3	...	3	2	12	74	0.58	
Magelona	43	26	40	37	16	40	78	33	27	30	29	50	44	493	3.88	
Chaetopterus	...	...	...	...	...	...	...	...	...	...	1	...	...	1	0.01
Cirriformia	285	337	7	70	419	185	73	124	43	38	52	153	238	2024	15.92	

Table 13. (continued)

Genus	2	5	6	7	8	9	10	11	14	16	17	18	19	Σ	% Composition
Mediomastus	14	11	37	108	25	82	72	47	47	97	117	57	45	759	5.97
Maldane	1	...	1	...	...	2	6	1	...	1	...	...	...	12	0.09
Myriowenia	...	...	...	...	...	...	...	...	...	...	...	...	1	1	0.01
Owenia	5	3	...	...	...	...	1	...	...	...	...	...	1	10	0.08
Sabellides	37	100	65	10	101	299	101	26	43	26	25	143	109	1085	8.53
Cossura	20	30	21	22	16	14	25	24	19	18	16	24	17	266	2.09
PELECYPODA															
Mulinia	2	368	2203	184	470	3	...	186	1118	836	457	731	8	6566	51.63
Abra	...	...	...	...	...	...	...	...	...	...	...	1	...	1	0.01
GASTROPODA															
Polinices	1	...	...	...	5	...	...	1	...	1	...	...	1	9	0.07
Epitonium	...	...	1	...	...	...	...	...	...	...	...	...	...	1	0.01
Nassarius	...	...	...	...	...	1	...	...	...	...	1	...	...	2	0.02
Vitrinella	...	...	...	...	...	1	1	...	...	...	...	...	...	2	0.02
ECHINODERMATA															
Micropholis	...	1	1	2	...	5	3	...	...	...	3	...	2	17	0.13
Holothuroidea	1	1	24	2	...	...	1	...	1	1	3	...	3	37	0.29
NEMATODA	...	...	...	...	...	2	3	...	1	...	...	1	1	8	0.06
CRUSTACEA															
Balanus	...	...	15	...	3	...	...	...	3	5	2	...	...	28	0.22
Diastylis	2	1	...	...	3	4	3	...	...	...	...	...	...	13	0.10
Ampelisca	...	...	...	...	...	9	45	...	...	...	...	...	...	54	0.42
Corophium	...	...	...	...	...	...	1	...	...	...	...	...	...	1	0.01
Callianassa	...	...	...	...	...	...	...	1	...	...	...	...	...	1	0.01
Polyonyx	...	...	...	...	...	...	...	...	...	...	1	...	...	1	0.01
Brachyura	...	...	...	...	...	...	...	...	2	...	...	...	...	2	0.02
Pinnixa	...	...	...	...	...	3	...	...	...	...	...	...	...	3	0.02

Table 13. (concluded)

Genus	2	5	6	7	8	9	10	11	14	16	17	18	19	Σ	% Composition
CNIDARIA															
Hydrozoa	...	...	...	...	...	...	...	...	1	...	1	...	...	2	0.02
Paranthus	...	...	...	1	...	...	...	...	...	1	1	...	...	3	0.02
Bunodactis	...	...	...	...	...	...	...	...	...	...	2	...	...	2	0.02
PLATYHELMINTHES															
Stylochus	4	1	...	1	7	1	...	...	...	...	...	...	...	14	0.11
NEMERTINA															
Cerebratulus	6	19	19	12	30	21	13	14	5	16	12	41	28	236	1.86
HEMICHORDATA															
Balanoglossus	...	...	...	...	...	2	...	...	...	...	...	...	...	2	0.02
CHORDATA															
Myrophis	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.01

Table 14. Individual biomass and sizes of some common benthic megafauna from West Hackberry.

Taxon	Number of Individuals Weighed	Length (mm)	Average Weight (g)
<u>Paraprionospio pinnata</u>	6	5 - 25	0.006
<u>Cirriformia</u> sp.	20	15	0.017
	20	20	0.030
	10	30	0.062
	1	35	0.424
<u>Aglaophamus verrilli</u>	3	15 - 20	0.020
<u>Haploscoloplos fragilis</u>	4	7 - 15	0.003
<u>Scolecoplepides viridis</u>	58	15 - 20	0.011
<u>Lumbrineris tenuis</u>	2	15 - 55	0.017
<u>Magelona</u> sp.	11	50	0.008
<u>Sigambra tentaculata</u>	8	5 - 7	0.006
<u>Glycera dibranchiata</u>	6	4 - 6	0.002
<u>Cossura delta</u>	8	3 - 4	0.001
<u>Mediomastus californiensis</u>	17	3 - 5	0.001
<u>Sabellides oculata</u>	12	2 - 3	0.0002
<u>Mulinia lateralis</u> (pelecypod)	50	1 - 2	0.002
	40	3 - 4	0.006
	50	5 - 6	0.041
	7	7 - 8	0.074
	25	9 - 10	0.121

Table 15. Bray-Curtis similarity index of stations occupied at West Hackberry

Station	2	5	6	7	8	9	10	11	14	16	17	18	19	$\bar{x} \pm$	SD
SUMMER CRUISE 1															
2	X	0.36	0.61	0.46	0.53	0.50	0.26	0.43	0.48	0.42	0.60	0.41	0.38	0.45 \pm 0.10	
5		X	0.28	0.40	0.24	0.34	0.29	0.21	0.27	0.16	0.23	0.13	0.23	0.26 \pm 0.08	
6			X	0.33	0.26	0.36	0.50	0.27	0.33	0.27	0.19	0.27	0.34	0.33 \pm 0.12	
7				X	0.35	0.49	0.31	0.32	0.43	0.26	0.30	0.35	0.30	0.36 \pm 0.07	
8					X	0.25	0.42	0.29	0.19	0.22	0.19	0.22	0.36	0.29 \pm 0.10	
9						X	0.45	0.43	0.22	0.38	0.37	0.35	0.38	0.38 \pm 0.08	
10							X	0.27	0.40	0.32	0.44	0.27	0.25	0.34 \pm 0.09	
11								X	0.36	0.30	0.25	0.15	0.27	0.30 \pm 0.08	
14									X	0.30	0.31	0.28	0.31	0.32 \pm 0.08	
16										X	0.21	0.20	0.17	0.27 \pm 0.08	
17											X	0.21	0.33	0.30 \pm 0.12	
18												X	0.26	0.26 \pm 0.08	
19													X	0.30 \pm 0.06	
FALL CRUISE 2															
2	X	0.24	0.39	0.31	0.21	0.34	0.35	0.36	0.30	0.25	0.48	0.23	0.29	0.31 \pm 0.08	
5		X	0.40	0.32	0.13	0.39	0.49	0.39	0.40	0.25	0.42	0.28	0.33	0.34 \pm 0.10	
6			X	0.28	0.34	0.51	0.55	0.09	0.26	0.25	0.14	0.43	0.52	0.35 \pm 0.15	
7				X	0.27	0.42	0.45	0.23	0.26	0.17	0.33	0.32	0.41	0.31 \pm 0.08	
8					X	0.35	0.41	0.33	0.35	0.24	0.37	0.25	0.32	0.30 \pm 0.08	
9						X	0.25	0.48	0.37	0.40	0.51	0.42	0.29	0.39 \pm 0.08	
10							X	0.53	0.40	0.47	0.53	0.38	0.28	0.42 \pm 0.10	
11								X	0.22	0.22	0.12	0.37	0.45	0.32 \pm 0.14	
14									X	0.24	0.26	0.26	0.43	0.31 \pm 0.07	
16										X	0.25	0.28	0.35	0.28 \pm 0.08	
17											X	0.39	0.47	0.36 \pm 0.14	
18												X	0.34	0.33 \pm 0.07	
19													X	0.37 \pm 0.08	

Table 15. (concluded)

Station	2	5	6	7	8	9	10	11	14	16	17	18	19	$\bar{x} \pm$	SD
WINTER CRUISE 3															
2	X	0.56	0.64	0.89	0.79	0.36	0.49	0.76	0.61	0.91	0.88	0.87	0.40	0.68 \pm 0.20	
5		X	0.77	0.58	0.48	0.60	0.71	0.37	0.20	0.70	0.60	0.65	0.45	0.56 \pm 0.16	
6			X	0.91	0.90	0.40	0.51	0.87	0.79	0.95	0.90	0.93	0.56	0.76 \pm 0.19	
7				X	0.13	0.87	0.90	0.28	0.51	0.31	0.10	0.25	0.81	0.55 \pm 0.32	
8					X	0.82	0.87	0.18	0.42	0.36	0.16	0.29	0.74	0.51 \pm 0.30	
9						X	0.30	0.79	0.62	0.92	0.89	0.88	0.34	0.65 \pm 0.24	
10							X	0.84	0.74	0.94	0.91	0.91	0.52	0.72 \pm 0.21	
11								X	0.31	0.47	0.31	0.39	0.70	0.52 \pm 0.25	
14									X	0.65	0.54	0.61	0.50	0.54 \pm 0.17	
16										X	0.25	0.17	0.88	0.63 \pm 0.30	
17											X	0.18	0.81	0.54 \pm 0.33	
18												X	0.85	0.58 \pm 0.31	
19													X	0.63 \pm 0.19	
SPRING CRUISE 4															
2	X	0.39	0.88	0.58	0.49	0.42	0.51	0.48	0.78	0.78	0.71	0.63	0.23	0.57 \pm 0.19	
5		X	0.67	0.47	0.14	0.53	0.60	0.39	0.51	0.47	0.36	0.33	0.38	0.44 \pm 0.14	
6			X	0.76	0.63	0.86	0.84	0.74	0.33	0.44	0.61	0.48	0.84	0.67 \pm 0.18	
7				X	0.54	0.58	0.48	0.19	0.58	0.46	0.29	0.51	0.56	0.50 \pm 0.15	
8					X	0.58	0.65	0.45	0.47	0.43	0.33	0.34	0.45	0.49 \pm 0.14	
9						X	0.39	0.55	0.79	0.75	0.67	0.54	0.28	0.58 \pm 0.17	
10							X	0.49	0.76	0.72	0.61	0.58	0.37	0.58 \pm 0.14	
11								X	0.58	0.51	0.37	0.44	0.45	0.47 \pm 0.13	
14									X	0.17	0.37	0.28	0.75	0.53 \pm 0.21	
16										X	0.25	0.20	0.73	0.49 \pm 0.22	
17											X	0.33	0.65	0.46 \pm 0.17	
18												X	0.50	0.43 \pm 0.13	
19													X	0.52 \pm 0.19	

*Bray-Curtis used on untransformed summed data for each three replicate grab samples per station per season (including Mulinia lateralis)

Table 16. Summation of benthic megafaunal counts of animals taken at Weeks Island site (Capline). Counts are of individuals taken in all three grabs combined.

Genus	Station													Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19		
Cruise 1															
POLYCHAETA															
Mediomastus	129	90	62	75	82	50	19	159	20	45	92	83	80	986	20.85
Paraprionospio	32	55	27	20	71	109	101	52	8	52	29	101	136	793	16.77
Magelona	22	49	9	8	12	43	48	37	5	18	6	52	37	346	7.32
Owenia	3	27	2	2	...	21	26	5	74	8	3	68	34	273	5.77
Haploscoloplos	1	17	16	16	8	5	3	6	19	23	22	3	2	141	2.98
Sigambra	4	16	8	11	4	10	19	12	17	3	1	13	5	123	2.60
Aglaophamus	7	11	5	3	18	18	15	6	...	7	2	15	14	121	2.56
Sthenelais	...	2	...	1	1	9	21	3	...	1	1	10	11	60	1.27
Polynoidae	2	2	...	...	...	...	...	...	...	...	...	1	...	5	0.11
Harmothoe	...	...	1	2	...	...	...	...	...	...	3	7	1	14	0.30
Pholoe	1	...	1	...	...	...	...	...	...	...	...	...	...	2	0.04
Phyllodoce	3	1	...	1	3	...	...	3	...	...	1	3	1	16	0.34
Ancistrosyllis	...	1	...	...	...	...	...	1	...	...	...	...	1	3	0.06
Eusyllis	1	1	...	...	...	6	2	5	2	...	...	...	5	22	0.47
Neanthes	...	1	...	2	1	2	...	...	...	1	3	...	...	10	0.21
Nereidae	...	1	...	...	...	...	2	...	...	...	2	1	2	8	0.17
Nephtys	...	1	...	...	...	...	...	...	...	2	...	...	1	4	0.08
Glycera	1	2	...	1	...	2	2	2	1	...	3	1	1	16	0.34
Diopatra	...	...	...	...	...	...	...	1	...	...	...	...	...	1	0.02
Onuphis	...	...	...	1	...	...	...	...	...	...	...	...	1	2	0.04
Lumbrineris	...	...	...	...	...	...	...	2	...	...	...	1	...	3	0.06
Ninoe	...	...	...	...	...	1	1	...	...	...	...	...	...	2	0.04
Prionospio	...	10	19	8	4	49	...	1	...	...	...	15	...	106	2.24
Cirriformia	5	17	...	...	1	10	4	3	20	4	2	25	1	92	1.95
Pherusa	...	...	...	...	1	...	...	...	...	...	...	...	...	1	0.02
Clymenella	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.02
Terbellidae	...	...	...	...	...	1	1	...	...	...	...	...	...	2	0.04
Pista	1	4	3	3	1	...	1	2	...	3	...	...	6	24	0.51
Megalomma	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.02
Cossura	...	1	...	...	...	...	2	...	...	...	...	...	...	3	0.06
Cistenides	...	...	1	...	1	...	...	...	...	...	...	1	...	3	0.06

Table 16. (continued)

Genus	Station													Σ	% Compo- sition
	2	5	6	7	8	9	10	11	14	16	17	18	19		
PELECYPODA															
Mulinia	66	...	63	3	111	...	16	23	5	60	16	...	...	363	7.68
Tellina	3	13	15	2	2	33	29	2	1	6	...	88	18	212	4.48
Pandora	1	...	1	...	...	...	...	...	...	...	...	...	...	2	0.04
Solen	...	...	1	...	...	1	...	...	...	...	...	...	...	2	0.04
Trachycardium	1	...	...	...	...	...	...	...	...	...	...	...	...	1	0.02
Lucina	...	...	...	...	1	...	...	...	...	...	...	...	...	1	0.02
Dosinia	...	...	...	...	...	1	2	...	...	...	...	...	...	3	0.06
Abra	...	...	...	...	...	...	...	...	...	...	...	2	...	2	0.04
GASTROPODA															
Nassarius	...	1	5	...	1	...	1	1	...	...	...	...	...	9	0.19
Sinum	...	...	1	...	...	...	...	...	...	...	...	1	...	2	0.04
Polinices	...	...	1	...	...	...	...	...	...	1	...	...	...	2	0.04
Olivella	...	...	1	...	1	...	...	...	...	...	...	...	...	2	0.04
Oliva	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.02
ECHINODERMATA															
Micropholis	4	7	3	...	3	5	2	...	62	1	4	14	1	106	2.24
Thyonella	...	...	2	...	...	...	...	...	...	...	...	...	...	2	0.04
NEMATODA															
	1	2	4	3	...	...	1	2	3	3	14	1	...	34	0.71
CRUSTACEA															
Harpacticoid															
copepod	...	...	...	...	...	...	...	...	1	1	...	...	...	2	0.04
Acartia	...	1	1	1	1	...	...	...	...	...	2	...	...	6	0.12
Labidocera	...	...	...	...	1	1	1	1	1	2	...	...	...	7	0.15
Mysidopsis	1	2	...	...	...	1	...	...	...	...	...	1	...	5	0.11
Diastylis	4	10	2	1	1	3	14	3	1	12	1	4	12	68	1.44
Almyracuma	...	...	...	1	...	...	...	...	...	...	...	...	...	1	0.02
Edotea	1	...	...	...	...	...	...	...	...	...	...	...	...	1	0.02
Ampelisca	1	21	12	1	1	20	50	...	6	8	5	2	9	136	2.87
Monoculoides	11	4	11	4	6	1	...	2	3	27	...	2	3	74	1.56
Penaeus	...	1	...	...	...	...	...	...	...	1	...	...	...	2	0.04
Ogyrides	9	6	9	4	6	1	3	2	...	4	3	10	12	69	1.46

Table 16. (continued)

Genus	Station														Σ	% Compo- sition
	2	5	6	7	8	9	10	11	14	16	17	18	19			
Leptochela	1	...	1	...	...	...	...	...	3	...	5	0.11	
Automate	1	...	1	0.02	
Callianassa	1	...	...	...	...	...	1	0.02	
Anomura	3	...	...	...	...	...	...	...	...	3	0.06	
Paguridae	2	...	...	...	...	1	4	7	0.15	
Euceramus	1	...	...	...	...	1	...	2	2	1	1	8	0.17	
Porcellanidae	1	...	...	...	...	...	...	...	...	...	...	1	0.02	
Emerita	1	...	...	...	...	...	...	1	0.02	
Albunea	2	2	...	2	1	...	...	...	3	10	0.21	
Lepidopa	1	...	1	0.02	
Brachyura	1	2	...	...	2	5	0.11	
Neopanope	1	...	...	...	...	...	...	...	...	1	...	2	0.04	
Pinnixa	1	...	...	...	...	...	...	3	4	0.08	
Persephona	1	...	...	...	...	...	...	2	3	0.06	
CNIDARIA																
Aurelia	1	...	...	1	2	0.04	
Actiniaria	5	...	...	...	...	...	...	1	...	18	...	...	...	24	0.51
Paranthus	...	19	13	21	28	3	...	25	34	24	87	11	8	273	5.77	
Sagartia	...	1	...	...	...	...	...	...	...	...	...	...	...	1	0.02
"sandy anemone"	2	...	2	0.04	
"stalked anemone"	1	...	1	...	...	...	...	...	...	...	...	2	0.04	
Haloclava	1	1	...	...	...	...	2	0.04	
PLATYHELMINTHES																
Polychadida	1	1	...	...	...	...	2	0.04	
NEMERTINA																
Cerebratulus	2	8	1	2	2	5	13	7	9	...	1	5	4	59	1.25	
CHAETOGNATHA																
Sagitta	1	...	...	1	...	...	...	...	1	1	...	...	1	5	0.11
CHORDATA																
Branchiostoma	1	...	1	...	2	0.04	
Cynoglossidae	...	1	...	1	...	...	...	...	1	...	...	...	...	3	0.06

Table 16. (continued)

G nus	Station													Σ	% Compo- sition
	2	5	6	7	8	9	10	11	14	16	17	18	19		
Cruise 2															
POLYCHAETA															
Harmothoe	...	...	1	...	...	...	...	...	...	...	...	...	...	1	0.06
Pholoe	...	1	...	...	...	...	...	...	2	1	1	...	...	5	0.30
Sthenelais	...	2	1	1	...	...	2	...	...	1	2	1	2	12	0.73
Linopherus	...	...	...	...	...	...	...	...	...	4	...	...	...	4	0.24
Ancistrosyllis	...	1	...	...	...	...	...	...	...	...	...	...	...	1	0.06
Sigambra	...	1	1	...	2	1	...	...	1	1	...	...	1	8	0.48
Eusyllis	...	1	...	...	...	1	...	...	...	...	...	...	...	2	0.12
Neanthes	...	6	8	2	10	1	...	...	...	...	1	1	3	32	1.94
Aglaophamus	31	23	8	2	20	41	70	9	12	17	10	43	37	323	19.56
Glycera	...	...	1	...	...	...	1	...	...	...	...	...	...	2	0.12
Diopatra	1	1	2	...	...	...	...	...	2	...	2	...	2	10	0.61
Lumbrineris	...	3	...	...	...	2	1	...	...	...	...	2	...	8	0.48
Haploscoloplos	2	...	22	44	18	1	...	6	16	13	28	1	6	157	9.51
Paraprionospio	2	6	11	8	9	3	3	7	1	3	20	5	6	84	5.09
Magelona	7	11	...	2	4	10	14	...	...	...	...	7	5	60	3.63
Cirriformia	...	...	...	...	...	...	...	...	4	...	...	...	...	4	0.24
Ammotrypane	...	...	1	2	1	...	...	...	2	2	1	...	...	9	0.55
Mediomastus	15	30	54	78	70	4	5	65	36	58	29	10	20	474	28.71
Clymenella	...	2	...	...	...	1	...	...	...	...	...	...	...	3	0.18
Owenia	...	...	...	1	...	1	...	...	1	...	...	2	2	7	0.42
Chone	...	1	...	...	...	...	...	1	3	4	1	...	3	13	0.79
PELECYPODA															
Mulinia	...	...	...	...	...	...	...	1	...	...	...	...	...	1	0.06
Tellina	...	10	3	...	...	...	1	4	...	1	...	3	6	28	1.70
Lucina	...	...	...	...	...	...	...	...	...	...	...	1	...	1	0.06
Dosinia	...	...	...	...	...	...	...	...	...	...	...	1	...	1	0.06
Abra	...	1	...	...	...	...	...	...	...	...	...	...	...	1	0.06
Chione	...	...	1	...	1	...	...	...	...	...	...	...	...	2	0.12
GASTROPODA															
Nassarius	4	2	7	7	8	8	3	4	6	8	6	2	2	67	4.06
Sinum	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.06

Tabl 16. (continued)

Genus	Station													Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19		
Olivella	...	...	...	...	...	...	...	...	...	...	1	...	...	1	0.06
Oliva	...	...	...	...	...	...	...	...	...	1	...	...	...	1	0.06
Tectonatica	...	...	...	1	1	...	1	...	...	...	...	...	...	3	0.18
Vitrinella	1	...	...	...	...	...	...	...	...	...	2	...	...	3	0.18
ECHINODERMATA															
Astropecten	...	...	...	...	...	...	1	...	...	...	...	...	...	1	0.06
Micropholis	...	3	...	...	...	...	2	...	...	...	...	...	...	5	0.30
NEMATODA	...	1	9	12	...	...	...	...	5	...	2	...	3	32	1.94
CRUSTACEA															
Harpacticoid															
copepod	1	...	5	9	6	...	...	1	...	8	8	...	...	38	2.30
Acartia	...	...	...	1	...	...	...	...	...	...	...	...	...	1	0.06
Labidocera	1	...	...	...	2	...	...	...	...	1	1	...	...	5	0.30
Mysidopsis	...	...	...	...	1	1	...	...	...	...	...	...	...	2	0.12
Mysis	...	...	...	...	...	...	...	...	...	...	1	...	...	1	0.06
Diastylis	...	...	...	...	1	...	...	1	1	2	1	...	...	6	0.36
Ampelisca	2	...	9	9	1	...	1	...	...	4	...	...	1	27	1.64
Monoculoides	...	...	1	3	4	...	...	3	3	5	6	2	1	28	1.70
Listriella	...	...	6	2	1	...	...	...	...	1	1	...	1	12	0.73
Penaeus	...	1	...	...	...	...	...	...	2	...	...	...	1	4	0.24
Lucifer	...	...	...	...	...	...	...	...	...	...	1	...	...	1	0.06
Ogyrides	...	4	5	2	14	3	2	12	3	7	3	9	6	70	4.24
Leptochela	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.06
Automate	...	1	1	...	...	...	...	...	...	...	...	...	...	2	0.12
Callianassa	...	1	...	...	...	...	...	...	...	...	...	...	...	1	0.06
Paguridae	4	3	3	2	6	1	3	2	1	1	10	2	2	40	2.42
Euceramus	...	...	...	...	...	...	...	...	...	1	...	1	1	3	0.18
Albunea	1	...	...	...	2	1	1	...	...	1	...	...	...	6	0.36
Brachyura	...	...	...	...	1	...	...	1	2	...	2	1	1	8	0.48
Xanthidae	...	...	...	...	...	...	...	...	...	...	1	3	...	4	0.24
Eurypanopeus	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.06
Pinnixa	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.06

Table 16. (continued)

Genus	Station														Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19			
CNIDARIA																
Hydrozoan	...	...	...	1	...	...	...	...	...	...	...	...	...	1	0.06
Paranthus	...	1	...	...	...	...	...	...	...	...	...	...	...	1	0.06
NEMERTINA																
Cerebratulus	1	...	1	...	...	...	...	1	1	...	...	...	2	6	0.36
CHAETOGNATHA																
Sagitta	...	...	1	1	3	1	...	...	...	1	3	2	...	12	0.73
CHORDATA																
Branchiostoma	...	...	1	...	1	...	...	...	...	...	...	...	...	2	0.12
CRUISE 3																
POLYCHAETA																
Harmothoe	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.08
Sthenelais	1	1	...	...	...	...	...	...	...	...	...	1	3	6	0.46
Linopherus	...	...	2	...	...	...	...	...	...	...	...	...	...	2	0.15
Phyllodoce	...	...	1	...	...	...	...	...	...	...	...	...	...	1	0.08
Sigambra	...	...	...	1	...	1	...	...	...	...	...	...	...	2	0.15
Neanthes	1	...	...	...	...	...	...	...	...	...	...	...	...	1	0.08
Nephtyidae	...	...	...	...	...	...	...	...	1	...	1	...	...	2	0.15
Aglaophamus	22	18	...	...	14	5	45	...	...	1	5	27	68	205	15.77
Glycera	...	2	...	...	...	...	...	...	1	...	1	1	...	5	0.38
Onuphis	...	...	...	1	...	...	...	...	1	...	1	...	...	3	0.23
Lumbrineris	...	...	...	...	...	...	...	...	...	...	...	1	...	1	0.08
Haploscoloplos	7	8	1	10	6	...	1	18	15	9	27	2	6	110	8.46	
Paraprionospio	3	6	...	...	...	...	...	4	2	...	10	...	8	33	2.54
Prionospio	31	5	...	...	1	...	1	...	2	...	...	...	...	40	3.08
Scolecoplepides	...	21	5	12	13	7	19	3	...	4	18	10	28	140	10.76	
Magelona	2	1	...	...	...	20	3	1	1	...	...	3	8	39	3.00
Ammotrypane	...	...	...	...	1	...	...	...	...	...	2	...	...	3	0.23
Mediomastus	23	18	7	11	13	11	11	14	30	10	16	12	19	195	15.00	
Maldanopsis	...	...	...	...	...	...	...	...	2	...	...	...	...	2	0.15

Table 16. (continued)

Genus	Station													Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19		
Owenia	1	1	...	...	...	...	...	...	...	...	...	...	2	4	0.31
Chone	...	...	1	...	...	...	...	...	...	...	...	...	...	1	0.08
Potamilla	...	...	...	...	...	...	...	...	...	...	...	1	...	1	0.08
PELECYPODA															
Mulinia	13	93	...	...	56	1	4	15	36	1	2	11	3	235	18.08
Tellina	4	8	...	...	7	...	5	3	1	...	...	1	7	36	2.77
Solen	...	...	...	...	...	...	1	...	...	...	...	...	...	1	0.08
Dosinia	1	...	...	...	...	...	...	...	...	...	...	...	...	1	0.08
Callocardia	...	...	...	...	...	1	...	...	...	...	...	2	...	3	0.23
Ensis	...	1	...	...	...	...	...	...	...	...	...	...	...	1	0.08
GASTROPODA															
Nassarius	...	4	2	3	1	...	2	3	3	1	2	8	6	35	2.69
Olivella	2	...	...	2	3	...	...	1	...	...	2	...	2	12	0.92
Tectonatica	1	...	...	1	3	...	...	3	2	...	...	2	...	12	0.92
Vitrinella	...	...	...	...	...	...	...	1	...	...	...	...	...	1	0.08
Strombiformis	...	...	...	...	...	...	1	...	...	...	...	...	...	1	0.08
ECHINODERMATA															
Astropecten	...	...	...	...	...	...	...	...	...	...	1	...	...	1	0.08
NEMATODA															
...	...	...	3	...	...	...	...	...	3	...	1	...	1	8	0.61
CRUSTACEA															
Cladocera	...	...	4	...	...	...	...	...	...	...	...	...	...	4	0.31
Ostracoda	...	...	...	1	...	...	...	...	...	...	...	...	...	1	0.15
Harpacticoid copepod	1	1	...	...	...	...	...	...	...	...	...	...	...	2	0.08
Temora	...	...	...	...	...	...	...	...	...	6	...	...	...	6	0.46
Labidocera	1	...	...	...	...	...	...	...	...	...	1	...	...	2	0.08
Ampelisca	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.15
Monoculoides	4	2	1	4	8	...	9	4	6	3	15	11	2	69	5.31
Listriella	6	...	...	1	...	...	1	...	2	...	5	...	...	15	0.50
Phoxoc phalida	...	...	...	...	...	...	...	...	2	...	...	...	...	2	0.08
Parametopella	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.15
Amphipod	...	...	1	...	...	...	...	...	...	...	...	...	...	1	0.15

Table 16. (continued)

Genus	Station													Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19		
Ogyrides	...	...	...	1	1	...	...	...	1	2	2	...	3	10	0.77
Leptochela	...	...	...	1	...	...	...	...	...	...	...	...	...	1	0.15
Pagurus	2	...	...	...	1	2	4	...	7	...	4	...	...	20	1.54
Albunea	1	...	...	...	...	...	1	...	...	...	...	...	...	2	0.08
Xanthidae	...	...	...	...	...	...	1	...	...	...	...	...	...	1	0.08
Pinnixa	...	...	...	...	...	1	2	...	...	...	1	...	1	5	0.38
CNIDARIA															
Calycella	...	...	...	...	...	...	...	...	...	...	1	...	1	2	0.15
Actiniaria	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.08
Paranthus	...	1	...	...	...	...	1	...	...	...	...	...	...	2	0.15
NEMERTINA															
Cerebratulus	1	...	...	...	...	...	...	...	...	...	...	...	...	1	0.08
Nemertian unidentified	...	...	2	...	...	...	...	...	...	...	...	...	...	2	0.15
CHAETOGNATHA															
Sagitta	...	1	2	...	...	...	...	...	...	...	...	...	...	3	0.23
SIPUNCULIDA															
Sagitta	...	...	...	...	...	...	1	...	...	...	...	...	...	1	0.08
CHORDATA															
Cephalochordata	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.08
Branchiostoma	...	...	...	...	...	...	...	...	1	...	...	...	...	1	0.08
Cruise 4															
POLYCHAETA															
Lepidasthenia	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.01
Pholoe	1	1	...	...	1	...	...	...	...	...	...	...	...	3	0.02
Sthenelais	...	...	1	...	1	1	...	...	...	...	...	...	...	3	0.02
Phyllodoce	6	5	6	3	6	7	3	5	2	6	4	...	7	60	0.49
Sigambra	...	...	...	...	...	...	...	1	...	...	...	...	...	1	0.01

Table 16. (continued)

Genus	Station														% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19	Σ	
Neanthes	...	...	1	2	...	...	...	1	3	...	...	...	...	7	0.06
Aglaophamus	4	16	...	1	5	17	38	2	...	3	1	3	11	101	0.82
Glycera	13	6	...	...	...	...	...	...	...	4	7	6	...	72	0.58
Onuphis	...	2	2	2	...	...	...	2	2	...	...	...	...	11	0.09
Lumbrineris	...	...	...	1	...	...	...	...	...	1	...	1	...	3	0.02
Haploscoloplos	4	4	17	46	3	2	...	15	18	16	23	...	8	156	1.26
Paraprionospio	13	1	...	2	...	4	7	1	...	2	...	126	5	161	1.30
Prionospio	...	1	...	...	...	...	3	...	...	1	...	...	...	5	0.04
Scolecoplepides	309	150	89	90	92	72	61	91	49	156	60	7	75	1301	10.52
Streblospio	...	...	...	1	...	...	...	...	...	...	...	...	...	1	0.01
Magelona	...	5	...	...	...	6	8	...	1	...	...	1	...	21	0.17
Cirriformia	...	...	...	1	...	...	...	...	...	...	...	...	...	1	0.01
Ammotrypane	1	1	...	...	...	...	...	...	...	...	1	...	...	3	0.02
Mediomastus	67	72	183	115	18	18	29	93	45	180	126	51	27	1024	8.28
Owenia	...	...	1	14	1	...	...	3	10	11	22	...	1	63	0.51
Sabellides	...	...	1	...	1	...	...	...	...	...	...	1	...	3	0.02
cf Aonides	...	...	...	...	...	...	2	...	...	...	...	...	...	2	0.02
PELECYPODA															
Mulinia	1822	37	674	39	510	2089	721	33	5	13	59	1521	789	8312	67.23
Tellina	...	...	...	...	...	1	1	...	...	1	...	2	3	8	0.06
Dosinia	...	1	...	1	...	...	...	...	...	2	...	...	...	4	0.03
GASTROPODA															
Nassarius	2	3	...	1	1	3	3	1	3	1	4	3	2	27	0.22
Olivia	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.01
Tectonatica	1	2	1	5	3	2	...	5	3	6	4	...	...	32	0.26
Mangelia	...	1	...	...	...	...	...	...	...	...	...	...	...	1	0.01
Olivella	...	1	...	3	...	...	...	...	...	4	2	...	...	10	0.08
Cantharus	...	...	...	...	...	...	1	...	...	...	...	...	...	1	0.01
Terebra	...	...	...	...	...	...	...	...	...	...	1	...	...	1	0.01
ECHINODERMATA															
Astropecten	1	...	...	...	...	...	...	...	...	...	...	...	...	1	0.01
Ophiuroidea	...	1	...	...	1	2	...	...	...	...	...	...	...	4	0.03

Table 16. (continued)

Genus	Station													Σ	% Composition
	2	5	6	77	8	9	10	11	14	16	17	18	19		
NEMATODA	4	...	286	45	1	...	...	7	2	9	16	4	1	375	3.03
CRUSTACEA															
Cladocera	1	...	...	4	...	3	...	1	2	...	1	...	...	12	0.10
Ostracoda	...	...	...	1	...	...	...	...	3	...	1	...	...	5	0.04
Harpacticoida															
copepod	...	...	1	...	...	...	...	1	...	...	...	...	...	2	0.02
Mysidopsis	...	...	1	...	...	...	...	...	...	1	...	...	...	2	0.02
Mysis	...	...	...	...	...	...	...	...	...	...	...	...	2	2	0.02
Diastylis	...	1	10	2	1	3	...	...	...	1	1	...	1	20	0.16
Cyclaspis	...	...	...	1	...	...	...	...	...	...	...	...	...	1	0.01
Almyracuma	...	...	...	1	...	...	...	...	...	1	...	...	...	2	0.02
Edotea	1	1	5	9	...	...	3	2	1	3	2	...	...	27	0.22
Ancinus	...	...	...	2	...	...	...	...	1	...	1	...	...	4	0.03
Ampelisca	...	1	...	...	...	...	...	...	...	1	...	...	...	2	0.02
Monoculoides	41	39	31	40	22	33	26	28	32	48	35	5	15	395	3.19
Listriella	1	1	1	3	2	2	1	...	...	6	1	...	...	18	0.15
Argissa	...	...	...	...	...	1	...	...	...	1	...	...	...	2	0.02
Corophium	...	...	...	...	...	...	...	2	...	...	...	...	...	2	0.02
Paraphoxus	...	...	...	...	...	...	...	1	3	...	...	...	...	4	0.03
Ericthonius	...	...	...	...	...	...	...	1	...	...	...	...	...	1	0.01
Penaeus	1	...	...	1	1	...	...	...	2	...	...	...	1	6	0.02
Lucifer	...	...	...	...	...	1	2	...	2	...	...	...	...	5	0.04
Ogyrides	...	1	1	2	...	1	1	1	...	1	...	...	1	9	0.07
Paguridae	7	1	2	...	3	1	...	1	1	1	...	...	3	20	0.16
Brachyura	...	...	...	...	...	...	...	...	1	1	...	...	...	2	0.02
Portunus	...	...	...	...	...	1	...	...	...	...	...	...	...	1	0.02
Callinectes	...	...	...	...	...	...	2	...	...	...	...	3	1	6	0.05
Pinnotheridae	...	...	...	...	...	3	1	...	...	...	...	...	...	4	0.03
CNIDARIA															
Calycella	...	...	...	...	...	...	2	...	...	...	...	...	1	3	0.02
Actiniaria	...	3	...	2	2	2	1	1	...	2	1	1	1	16	0.13

Table 16. (concluded)

Genus	Station														Σ	% Composition
	2	5	6	7	8	9	10	11	14	16	17	18	19			
PLATYHELMINTHES																
Stylochus	...	...	1	...	...	...	...	1	...	...	...	...	...	2	0.02	
NEMERTINA																
Cerebratulus	2	...	...	...	...	...	...	...	1	...	2	...	...	5	0.04	
Nemertian	...	...	...	...	...	...	...	...	...	...	1	...	...	1	0.01	
SIPUNCULIDA																
	...	...	...	...	...	...	1	...	...	1	...	...	1	3	0.02	

Table 17. Seasonal counts of megafauna by species at the Weeks Island site.

Taxa	Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
PHYLUM CNIDARIA					
Class Hydrozoa					
Unidentified	...	1	...	...	1
<u>Calycella syringa</u>	...	...	2	3	5
Class Scyphozoa					
<u>Aurelia aurita</u>	2	...	...	...	2
Class Anthozoa					
Order Actiniaria -juvenile	24	...	1	16	41
<u>Paranthus rapiformis</u>	273	1	2	...	276
<u>Sagartia modesta</u>	1	...	...	...	1
"sandy anemone"	2	...	...	...	2
"stalked anemone"	2	...	...	...	2
Order Ceriantharia					
<u>Haloclava</u> sp.	2	...	...	...	2
PHYLUM PLATYHELMINTHES					
Order Polycladida	2	...	...	...	2
<u>Stylochus ellipticus</u>	...	...	...	2	2
PHYLUM NEMERTINA					
<u>Cerebratulus lacteus</u>	59	6	1	5	71
Unidentified nemertian	...	...	2	1	3
PHYLUM ASCHELMINTHES					
Class Nematoda	34	32	8	375	449
PHYLUM ANNELIDA					
Class Polychaeta					
Family Polynoidae -juvenile	5	...	...	...	5

Table 17. (continued)

Taxa	Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
<u>Harmothoe aculeata</u>	14	1	1	...	16
<u>Lepidasthenia varia</u>	...	...	...	1	1
Family Sigalionidae					
<u>Pholoe minuta</u> cf	2	5	...	3	10
<u>Sthenelais boa</u>	60	12	6	3	81
Family Amphinomidae					
<u>Linopherus ambigua</u>	...	4	2	...	6
Family Phyllodocidae					
<u>Phyllodoce arenae</u>	13	...	1	7	21
<u>Phyllodoce mucosa</u>	3	...	...	47	50
<u>Phyllodoce</u> sp. -juvenile	...	...	...	6	6
Family Pilargidae					
<u>Ancistrosyllis papillosa</u>	3	1	...	...	4
<u>Sigambra tentaculata</u>	123	8	2	1	134
Family Syllidae					
<u>Eusyllis</u> sp.	22	2	...	...	24
Family Nereidae -juvenile	8	...	...	...	8
<u>Neanthes succinea</u>	10	32	1	7	50
Family Nephtyidae -juvenile	...	...	2	...	2
<u>Aglaophamus verrilli</u>	121	323	205	101	750
<u>Nephtys picta</u>	4	...	...	...	4
Family Glyceridae					
<u>Glycera americana</u>	5	1	...	47	53
<u>Glycera capitata</u>	6	...	1	...	7
<u>Glycera dibranchiata</u>	5	1	4	25	35
Family Onuphidae					
<u>Diopatra cuprea</u>	1	10	...	...	11
<u>Onuphis eremita</u>	2	...	3	11	16

Table 17. (continued)

Taxa	Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
Family Lumbrineridae					
<u>Lumbrineris impatiens</u>	2	...	...	...	2
<u>Lumbrineris tenuis</u>	1	8	1	3	13
<u>Ninoe nigripes</u>	2	...	...	...	2
Family Orbiniidae					
<u>Haploscoloplos fragilis</u>	141	157	110	156	564
Family Spionidae					
<u>Paraprionospio pinnata</u>	793	84	33	161	1071
<u>Prionospio cirrifera</u>	106	...	40	5	151
<u>Scolecopides viridis</u>	...	...	140	1301	1441
<u>Streblospio</u> sp.	...	...	...	1	1
Family Magelonidae					
<u>Magelona</u> sp.	336	59	39	21	455
<u>Magelona</u> sp. #2	10	1	...	...	11
Family Cirratulidae					
<u>Cirriformia</u> sp.	92	4	...	1	97
Family Flabelligeridae					
<u>Pherusa</u> sp.	1	...	...	...	1
Family Opheliidae					
<u>Ammotrypane aulogaster</u>	...	9	3	3	15
Family Capitellidae					
<u>Mediomastus californiensis</u>	986	474	195	1024	2679
Family Maldanidae					
<u>Clymenella torquata</u>	1	3	...	...	4
<u>Maldanopsis elongata</u>	...	...	2	...	2
Family Oweniidae					
<u>Owenia fusiformis</u>	273	7	4	63	347
Family Ampharetidae					
<u>Sabellides oculata</u>	...	...	...	3	3

Table 17. (continued)

Taxa		Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
Family Terebellidae	-juvenile	2	...	...	...	2
	<u>Pista palmata</u>	24	...	...	...	24
Family Sabellidae						
	<u>Chone dumeri</u>	...	13	1	...	14
	<u>Megalomma bioculatum</u>	1	...	...	...	1
	<u>Potamilla reniformis</u>	...	...	1	...	1
Family Cossuridae						
	<u>Cossura delta</u>	3	...	...	...	3
Family Pectinariidae						
	<u>Cistenides gouldi</u>	3	...	...	...	3
...						
	cf <u>Aonides</u> sp.	...	...	...	2	2
PHYLUM MOLLUSCA						
Class Gastropoda						
	<u>Nassarius acutus</u>	9	67	35	27	138
	<u>Sinum perspectivum</u>	2	1	...	...	3
	<u>Polinices duplicatus</u>	2	...	...	...	2
	<u>Olivella minuta</u>	2	1	4	...	7
	<u>Oliva sayana</u>	1	1	...	1	3
	<u>Tectonatica pusilla</u>	...	3	12	32	47
	<u>Vitrinella floridana</u>	...	3	1	...	4
	<u>Mangelia cerina</u>	...	...	...	1	1
	<u>Olivella dealbata</u>	...	...	8	10	18
	<u>Strombiformis bilineata</u>	...	...	1	...	1
	<u>Cantharus cancellarius</u>	...	...	...	1	1
	<u>Terebra protexta</u>	...	...	...	1	1
Class Pelecypoda						
	<u>Mulinia lateralis</u>	363	1	235	8312	8911
	<u>Tellina versicolor</u>	212	28	36	8	284
	<u>Pandora trilineata</u>	2	...	...	...	2

Tabl .17. (continued)

Taxa	Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
<u>Solen viridis</u>	2	...	1	...	3
<u>Trachycardium muricatum</u>	1	...	...	...	1
<u>Lucina amiantus</u>	1	1	...	...	2
<u>Dosinia discus</u>	3	1	1	4	9
<u>Abra aequalis</u>	2	1	...	...	3
<u>Chione cancellata</u>	...	2	...	...	2
<u>Callocardia texasiana</u>	...	...	3	...	3
<u>Ensis minor</u>	...	...	1	...	1
PHYLUM ARTHROPODA					
Class Crustacea					
Subclass Branchiopoda					
Order Cladocera	...	...	4	12	16
Subclass Ostracoda					
	...	...	1	5	6
Subclass Copepoda					
Order Harpacticoida					
Harpacticoid copepod	2	38	2	2	44
<u>Acartia</u> sp.	6	1	...	...	7
<u>Temora</u> sp.	...	...	6	...	6
<u>Labidocera</u> sp.	7	5	2	...	14
Subclass Malacostraca					
Superorder Peracarida					
Order Mysidacea					
<u>Mysidopsis</u> sp. -juvenile	5	...	...	1	6
<u>Mysidopsis bigelowi</u>	...	2	...	1	3
<u>Mysis mixta</u>	...	1	...	2	3
Order Cumacea					
<u>Diastylis</u> sp.	68	6	...	20	94
<u>Cyclaspis varians</u>	...	...	...	1	1
<u>Almyracuma proximoculi</u>	1	...	...	2	3

Table 17. (continued)

Taxa	Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
Order Isopoda					
<u>Edotea</u> sp.	1	...	...	27	28
<u>Ancinus depressus</u>	...	...	...	4	4
Order Amphipoda					
<u>Ampelisca</u> sp.	136	27	1	2	166
<u>Monoculoides</u> sp.	74	28	69	395	566
<u>Listriella</u> sp. cf	...	12	15	18	45
<u>Phoxocephalidae</u>	...	...	2	...	2
<u>Parametopella cypris</u> cf	...	...	1	...	1
Unidentified amphipod	...	...	1	...	1
<u>Argissa</u> sp.	...	...	...	2	2
<u>Corophium</u> sp.	...	...	...	2	2
<u>Paraphoxus</u> sp.	...	...	...	4	4
<u>Erichthonius rubricornis</u>	...	...	...	1	1
Superorder Eucarida					
Order Decapoda					
Section Penaeidea					
<u>Penaeus setiferus</u>	2	4	...	...	6
<u>Penaeus setiferus</u> -larvae	...	...	...	6	6
<u>Lucifer faxoni</u>	...	1	...	5	6
Section Caridea					
<u>Ogyrides limicola</u>	69	70	10	9	158
<u>Leptochela serratorbita</u>	5	1	1	...	7
<u>Automate</u> sp.	1	2	...	...	3
Section Macrura					
<u>Callianassa</u> sp.	1	...	...	...	1
<u>Callianassa latispina</u>	...	1	...	...	1
Section Anomura -zoea	3	...	...	...	3

Table 17. (continued)

Taxa		Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
Family Paguridae	-juvenile	7	40	...	19	66
	<u>Pagurus longicarpus</u>	...	...	16	...	16
	<u>Pagurus bullisi</u>	...	...	4	...	4
	<u>Pagurus cf moorei</u>	...	...	...	1	1
Family Porcellanidae	-zoea	1	...	...	...	1
	<u>Eucramus praelongus</u>	8	3	...	...	11
Family Hippidae						
	<u>Emerita</u> sp. -juvenile	1	...	...	...	1
Family Albuneidae						
	<u>Albunea paretii</u>	10	6	2	...	18
	<u>Lepidopa websteri</u>	1	...	...	...	1
Section Brachyura	-juvenile	5	8	...	2	15
Family Portunidae						
	<u>Portunus gibbesii</u> -juvenile	...	...	...	1	1
	<u>Callinectes cf similis</u> -juvenile	...	...	...	6	6
Family Xanthidae	-juvenile	...	4	1	...	5
	<u>Neopanope texana</u>	2	...	...	...	2
	<u>Eurypanopeus</u> sp.	...	1	...	...	1
Family Pinnotheridae	-juvenile	...	...	...	4	4
	<u>Pinnixa cylindrica</u>	1	...	...	...	1
	<u>Pinnixa chaetopterana</u>	3	1	1	...	5
	<u>Pinnixa sayana</u>	...	...	4	...	4
Family Leucosiidae						
	<u>Persephona mediterranea</u>	3	...	...	...	3
PHYLUM SIPUNCULIDA		...	...	1	3	4
PHYLUM ECHINODERMATA						
Subclass Asteroidea						
	<u>Astropecten antillensis</u>	...	1	1	1	3

Table 17.. (concluded)

Taxa	Summer (June)	Fall (November)	Winter (January)	Spring (April)	Total
Subclass Ophiuroidea	...	...	...	4	4
<u>Micropholis atra</u>	106	5	...	...	111
Class Holothuroidea					
<u>Thyonella gemmata</u>	2	...	...	...	2
PHYLUM CHAETOGNATHA					
<u>Sagitta</u> sp.	5	12	3	...	20
PHYLUM CHORDATA					
SUBPHYLUM CEPHALOCHORDATA					
<u>Branchiostoma</u> sp.	2	2	1	...	5
SUBPHYLUM VERTEBRATA					
Class Osteichthyes					
Family Cynoglossidae -juvenile	<u>3</u>	<u>...</u>	<u>...</u>	<u>...</u>	<u>3</u>
Total number of species	90	65	64	71	146
Total individuals	4,728	1,651	1,300	12,364	20,044

Table 18. Bray-Curtis similarity index of stations occupied at Weeks Island

Station	2	5	6	7	8	9	10	11	14	16	17	18	19	\bar{x}	\pm	SD
SUMMER CRUISE 1																
2	X	0.46	0.34	0.49	0.35	0.62	0.65	0.31	0.79	0.38	0.48	0.57	0.52	0.50	\pm	0.14
5		X	0.43	0.38	0.42	0.34	0.40	0.34	0.55	0.43	0.46	0.33	0.32	0.41	\pm	0.07
6			X	0.35	0.35	0.54	0.56	0.50	0.67	0.38	0.45	0.62	0.57	0.48	\pm	0.11
7				X	0.48	0.61	0.75	0.42	0.60	0.49	0.40	0.59	0.54	0.51	\pm	0.12
8					X	0.54	0.63	0.41	0.73	0.36	0.46	0.52	0.47	0.48	\pm	0.12
9						X	0.29	0.53	0.70	0.57	0.68	0.37	0.35	0.51	\pm	0.14
10							X	0.54	0.68	0.56	0.73	0.44	0.35	0.55	\pm	0.15
11								X	0.68	0.44	0.43	0.49	0.44	0.46	\pm	0.10
14									X	0.64	0.63	0.60	0.71	0.67	\pm	0.07
16										X	0.48	0.61	0.51	0.49	\pm	0.09
17											X	0.64	0.59	0.54	\pm	0.11
18												X	0.30	0.51	\pm	0.12
19													X	0.47	\pm	0.13
FALL CRUISE 2																
2	X	0.40	0.64	0.73	0.67	0.29	0.38	0.60	0.54	0.56	0.61	0.30	0.29	0.50	\pm	0.16
5		X	0.44	0.59	0.56	0.43	0.48	0.48	0.42	0.43	0.46	0.36	0.28	0.44	\pm	0.08
6			X	0.24	0.23	0.70	0.77	0.30	0.32	0.46	0.29	0.62	0.52	0.46	\pm	0.19
7				X	0.27	0.77	0.83	0.39	0.42	0.35	0.35	0.71	0.62	0.52	\pm	0.21
8					X	0.60	0.69	0.27	0.33	0.20	0.35	0.53	0.46	0.43	\pm	0.18
9						X	0.28	0.72	0.60	0.60	0.67	0.21	0.32	0.52	\pm	0.20
10							X	0.74	0.73	0.69	0.74	0.32	0.42	0.59	\pm	0.20
11								X	0.39	0.27	0.48	0.58	0.53	0.48	\pm	0.16
14									X	0.23	0.29	0.57	0.46	0.44	\pm	0.15
16										X	0.35	0.54	0.45	0.43	\pm	0.15
17											X	0.60	0.51	0.48	\pm	0.15
18												X	0.21	0.46	\pm	0.17
19													X	0.42	\pm	0.12

Table 18. (concluded)

Station	2	5	6	7	8	9	10	11	14	16	17	18	19	\bar{x}	\pm	SD
WINTER CRUISE 3																
2	X	0.51	0.85	0.68	0.54	0.77	0.52	0.52	0.52	0.66	0.64	0.48	0.55	0.60	\pm	0.12
5		X	0.81	0.68	0.29	0.78	0.56	0.60	0.52	0.74	0.59	0.54	0.50	0.59	\pm	0.14
6			X	0.53	0.80	0.67	0.68	0.73	0.70	0.42	0.67	0.70	0.82	0.70	\pm	0.12
7				X	0.56	0.60	0.58	0.43	0.60	0.30	0.46	0.55	0.64	0.55	\pm	0.11
8					X	0.71	0.50	0.49	0.45	0.67	0.57	0.51	0.58	0.56	\pm	0.13
9						X	0.63	0.74	0.80	0.64	0.65	0.60	0.70	0.69	\pm	0.07
10							X	0.67	0.70	0.64	0.51	0.34	0.32	0.55	\pm	0.13
11								X	0.41	0.50	0.48	0.51	0.66	0.56	\pm	0.11
14									X	0.61	0.50	0.62	0.73	0.60	\pm	0.12
16										X	0.55	0.66	0.72	0.59	\pm	0.13
17											X	0.55	0.54	0.56	\pm	0.07
18												X	0.49	0.55	\pm	0.09
19													X	0.60	\pm	0.14
SPRING CRUISE 4																
2	X	0.76	0.51	0.80	0.55	0.14	0.47	0.81	0.88	0.78	0.81	0.20	0.42	0.59	\pm	0.25
5		X	0.70	0.33	0.62	0.85	0.70	0.23	0.43	0.27	0.38	0.89	0.72	0.57	\pm	0.23
6			X	0.59	0.34	0.55	0.28	0.65	0.78	0.75	0.62	0.51	0.28	0.55	\pm	0.17
7				X	0.65	0.86	0.74	0.20	0.42	0.29	0.21	0.89	0.74	0.56	\pm	0.26
8					X	0.56	0.21	0.62	0.74	0.70	0.66	0.54	0.21	0.53	\pm	0.18
9						X	0.45	0.87	0.92	0.88	0.86	0.22	0.43	0.63	\pm	0.28
10							X	0.73	0.76	0.78	0.70	0.41	0.09	0.53	\pm	0.24
11								X	0.32	0.30	0.25	0.89	0.72	0.55	\pm	0.27
14									X	0.47	0.38	0.92	0.80	0.65	\pm	0.23
16										X	0.32	0.91	0.78	0.60	\pm	0.25
17											X	0.84	0.72	0.56	\pm	0.24
18												X	0.37	0.63	\pm	0.29
19													X			

*Bray-Curtis used on untransformed summed data for each three replicate grab samples per station per season

Table 19. List of species observed as dead shell found at both the West Hackberry and Weeks Island sites.

PELECYPODA

Common*

Mulinia lateralis
Nuculana concentrica
Abra aequalis
Tellina versicolor

Occasional

Anadara ovalis
Anadara transversa
Macoma brevisfrons
Dosinia discus

Rare

Pandora trilineata
Anomia simplex
Lucina amiantus
Lucina multilineata
Callocardia texasiana
Solen viridis
Amygdalum papyria**
Chione cancellata
Nuculana acuta
Raeta plicatella
Ostrea equestris
Corbula contracta
Macoma tenta

GASTROPODA

Common

Nassarius acutus

Occasional

Tectonatica pusilla
Polinices duplicatus
Terebra protecta
Cantharus cancellarius
Thais haemastoma
Retusa canaliculata
Oliva sayana***
Turbonilla interrupta
Anachis obesa
Vitrinella floridana

Rare

Epitonium multistriatum
Epitonium humphreysi
Epitonium angulatum
Haminoea antillarum**
Odostomia sp.
Mangelia cerina
Cyclostremiscus jeannae
Cerithiopsis emersonii
Mangelia plicosa
Sinum perspectivum
Busycon sp.***
Olivella dealbata***

SCAPHOPODA

Rare

Dentalium texasianum

*Common: in over half of the samples

Occasional: in approximately one-tenth of the samples

Rare: in less than one-tenth of the samples

*Found at West Hackberry only

**Found at Weeks Island only

Table 20. Mean number meiofauna ($<63\mu$) counted per
10 cm² by site and season.

Season	West Hackberry	Weeks Island
Summer (June)	1613 \pm 1193	2902 \pm 1197
Fall (November)	717 \pm 649	1073 \pm 1231
Winter (January)	761 \pm 329	1055 \pm 596
Spring (May)	509 \pm 402	1885 \pm 1011

Table 21. Percent composition of meiofauna by site and season.

	Summer (June)	Fall (November)	Winter (January)	Spring (May)
WEEKS ISLAND				
Nematodes (%)	76.65	97.31	98.01	98.67
Tintinnids (%)	20.26	...	...	...
Harpacticoid copepods (%)	1.30	2.12	1.25	0.64
Kinorhynchs (%)	0.08	0.04	0.01	...
Polychaetes (%)	0.36	0.12	0.60	0.17
Turbellarians (%)	0.27	...	...	0.16
Pelecypods (%)	0.07	0.17	0.09	0.15
WEST HACKBERRY				
Nematodes (%)	61.00	99.48	95.78	93.35
Tintinnids (%)	27.56	...	...	...
Harpacticoid copepods (%)	0.30	...	0.69	1.51
Kinorhynchs (%)	3.79	...	1.80	0.91
Polychaetes (%)	0.27	0.35	0.99	0.85
Turbellarians (%)	1.55	...	...	...
Pelecypods (%)	0.05	0.01	0.24	0.16
Tardigrades (%)	2.90	...	...	2.26

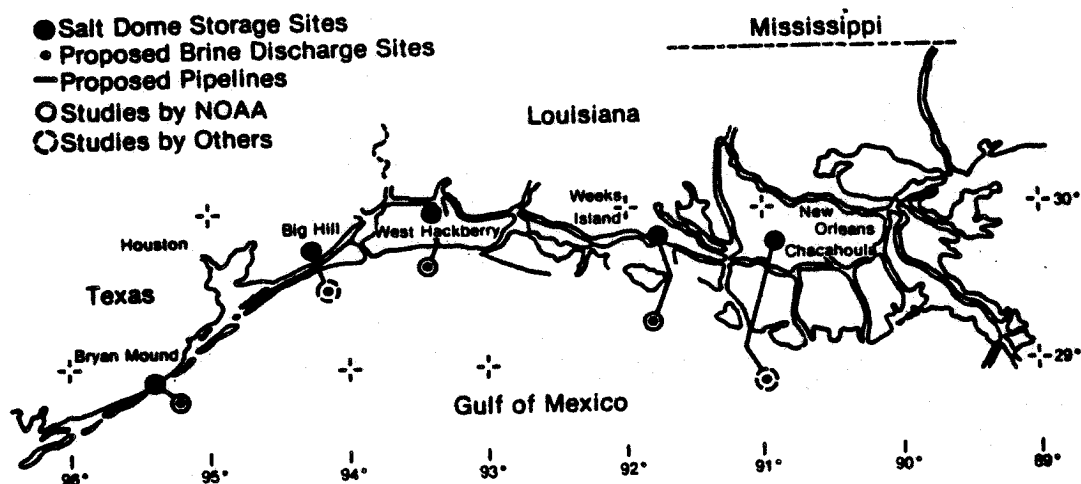


Figure 1. Proposed brine disposal locations. Source: U.S. Department of Commerce, NOAA (1978)

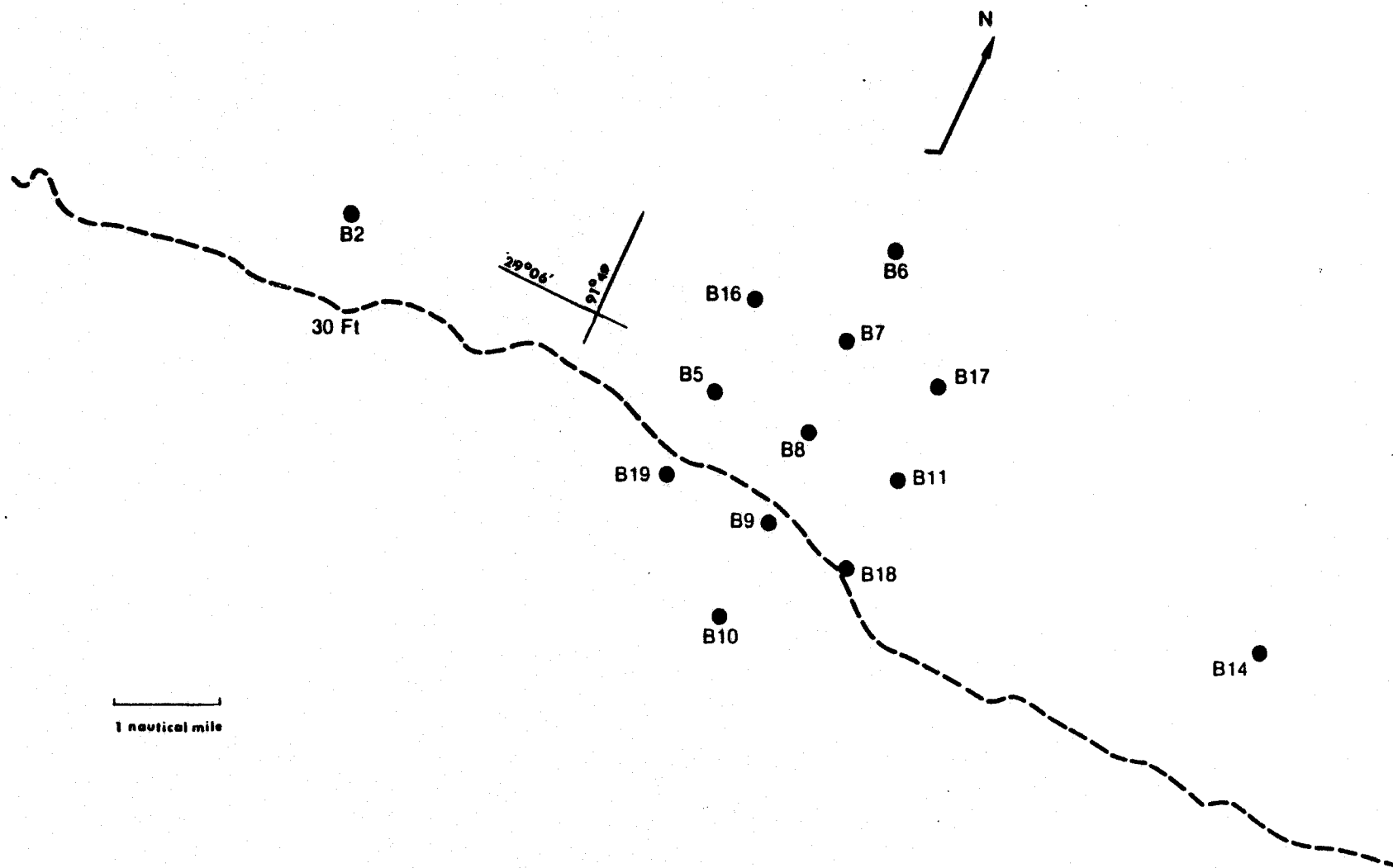


Figure 2. Benthic biological sampling station locations, We ks Island. Source: U.S. Department of Commerce, NOAA (1978)

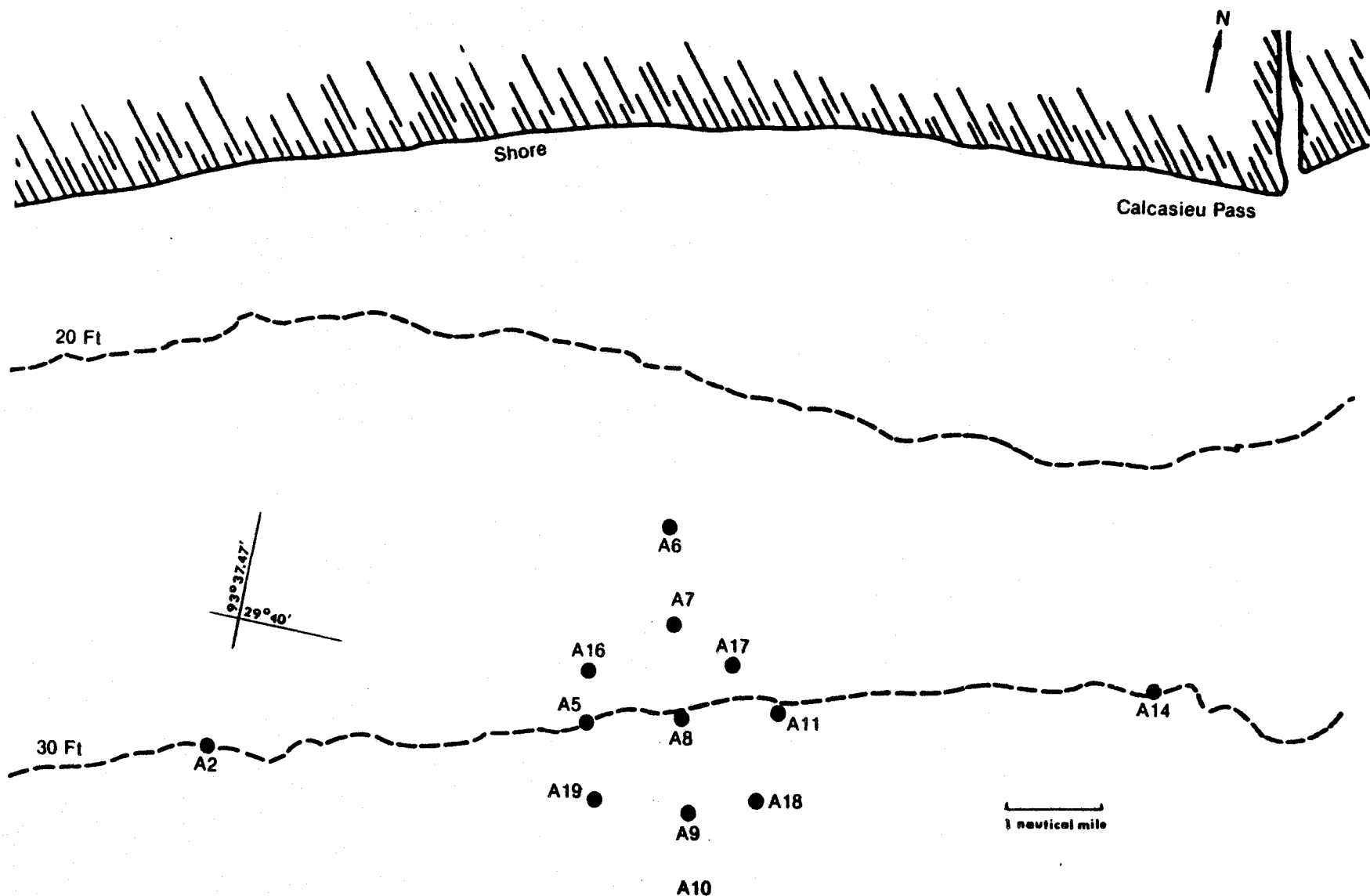


Figure 3. Benthic biological sampling station locations, West Hackberry. Source: U.S. Department of Commerce, NOAA (1978)

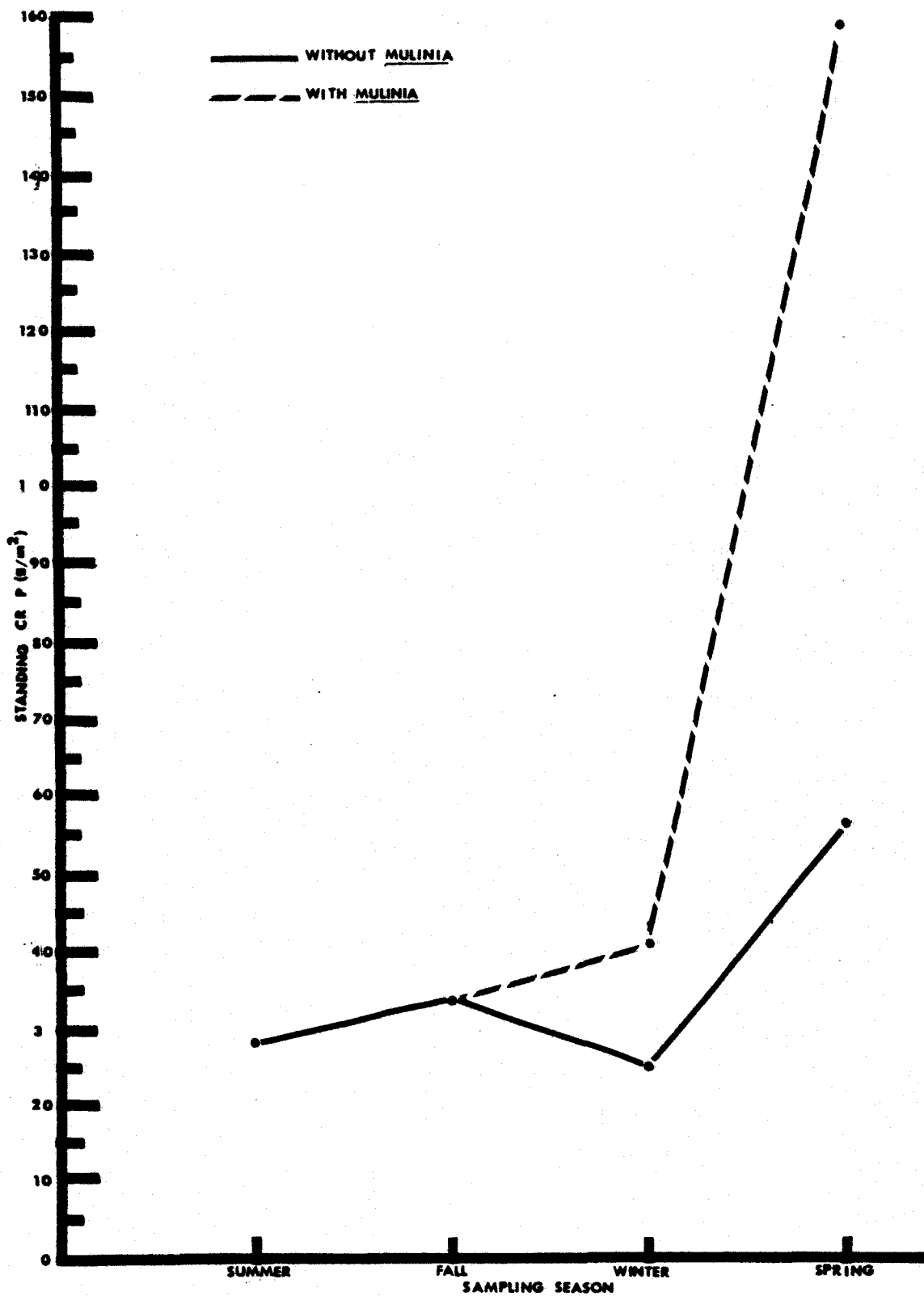


Figure 4. Mean biomass of the standing crop of megafauna as grams per square meter (g/m^2) at the West Hackberry site.

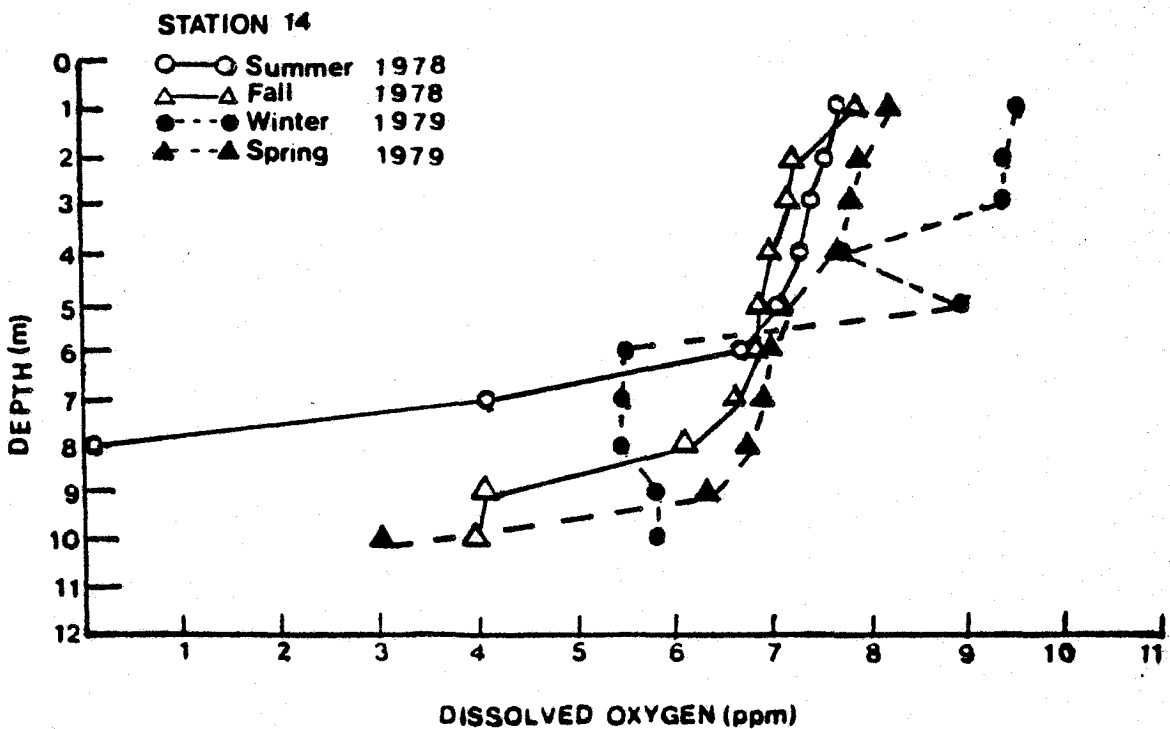
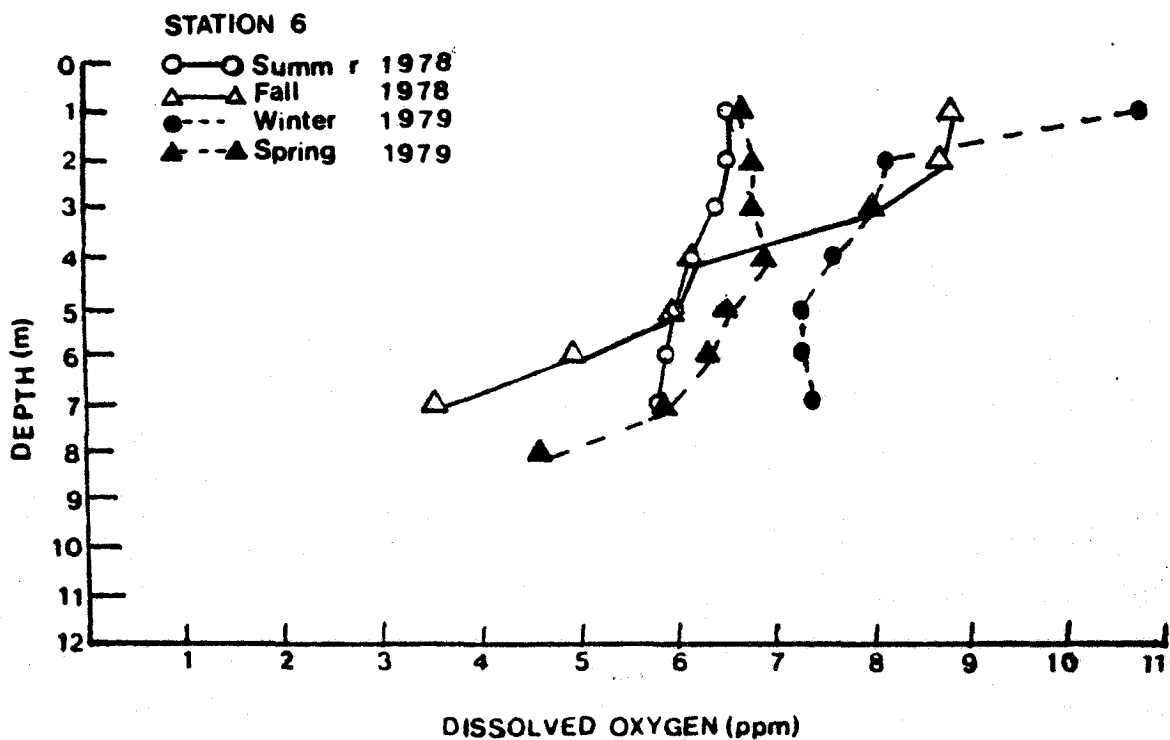


Figure 5. Dissolved oxygen profiles for all seasons at stations 6 and 14, West Hackberry site.

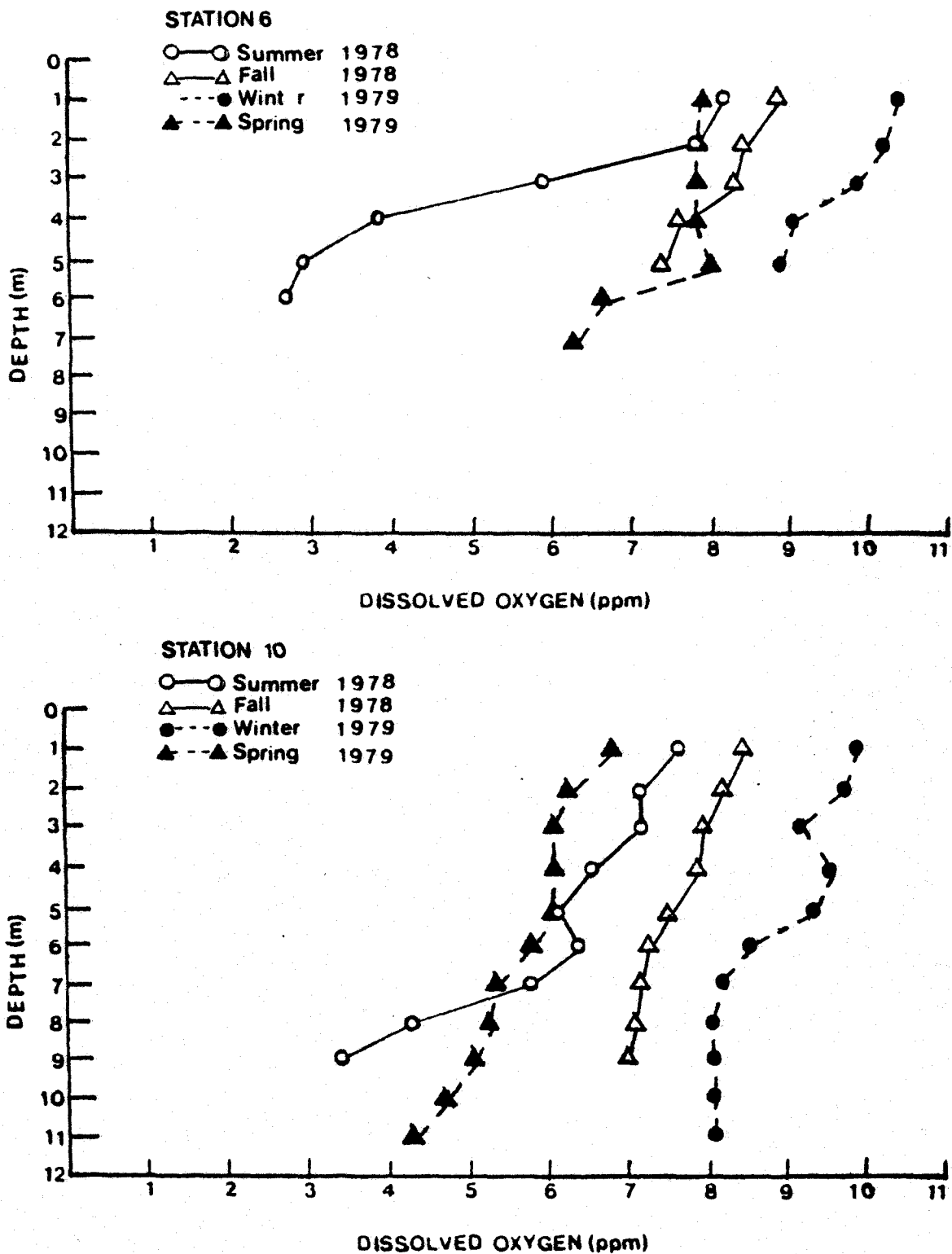


Figure 6. Dissolved oxygen profiles for all seasons at stations 6 and 10, Weeks Island site.

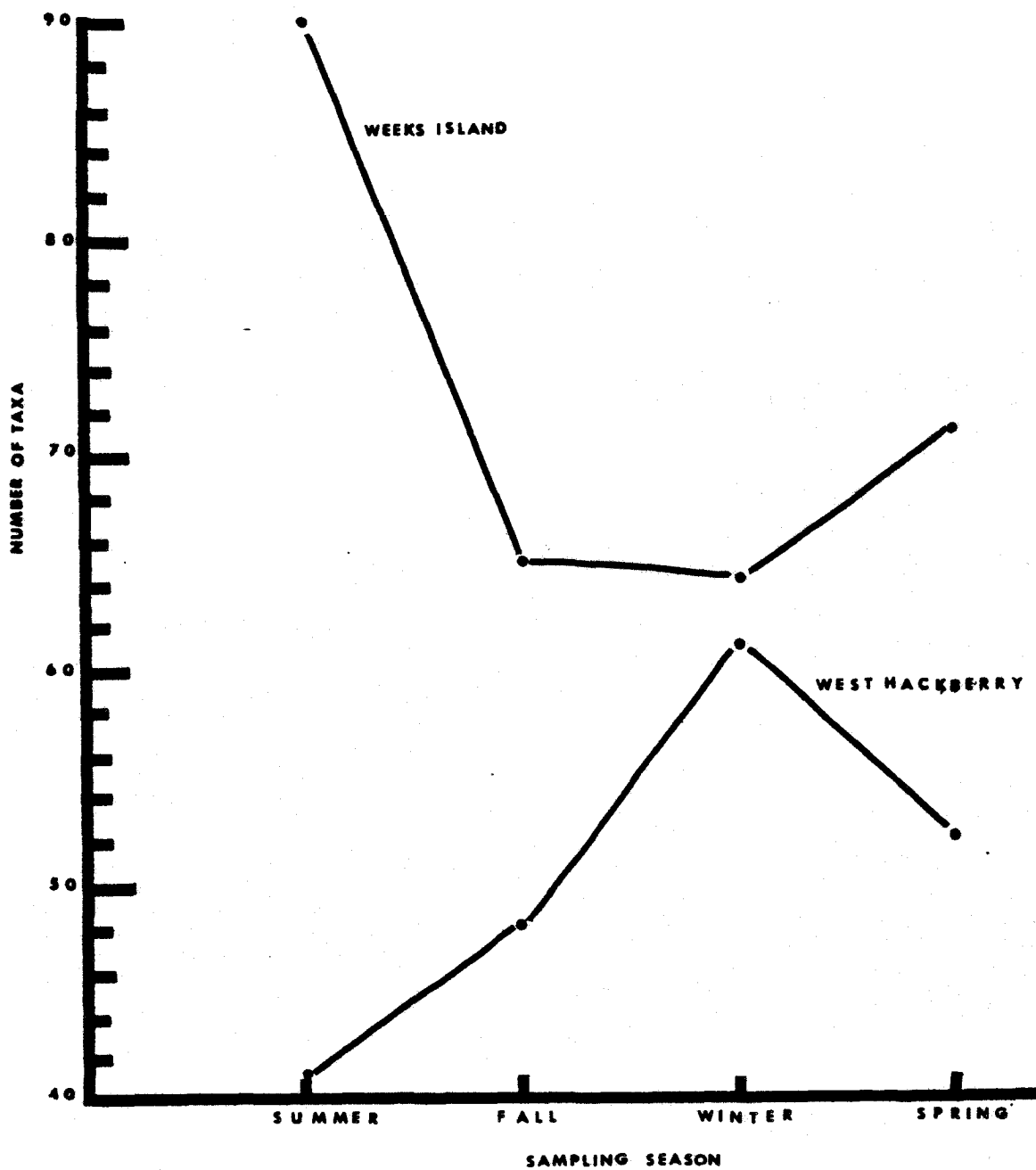


Figure 7. Comparison of numbers of different megafauna taxa by site and season for both the West Hackberry and Weeks Island sites.

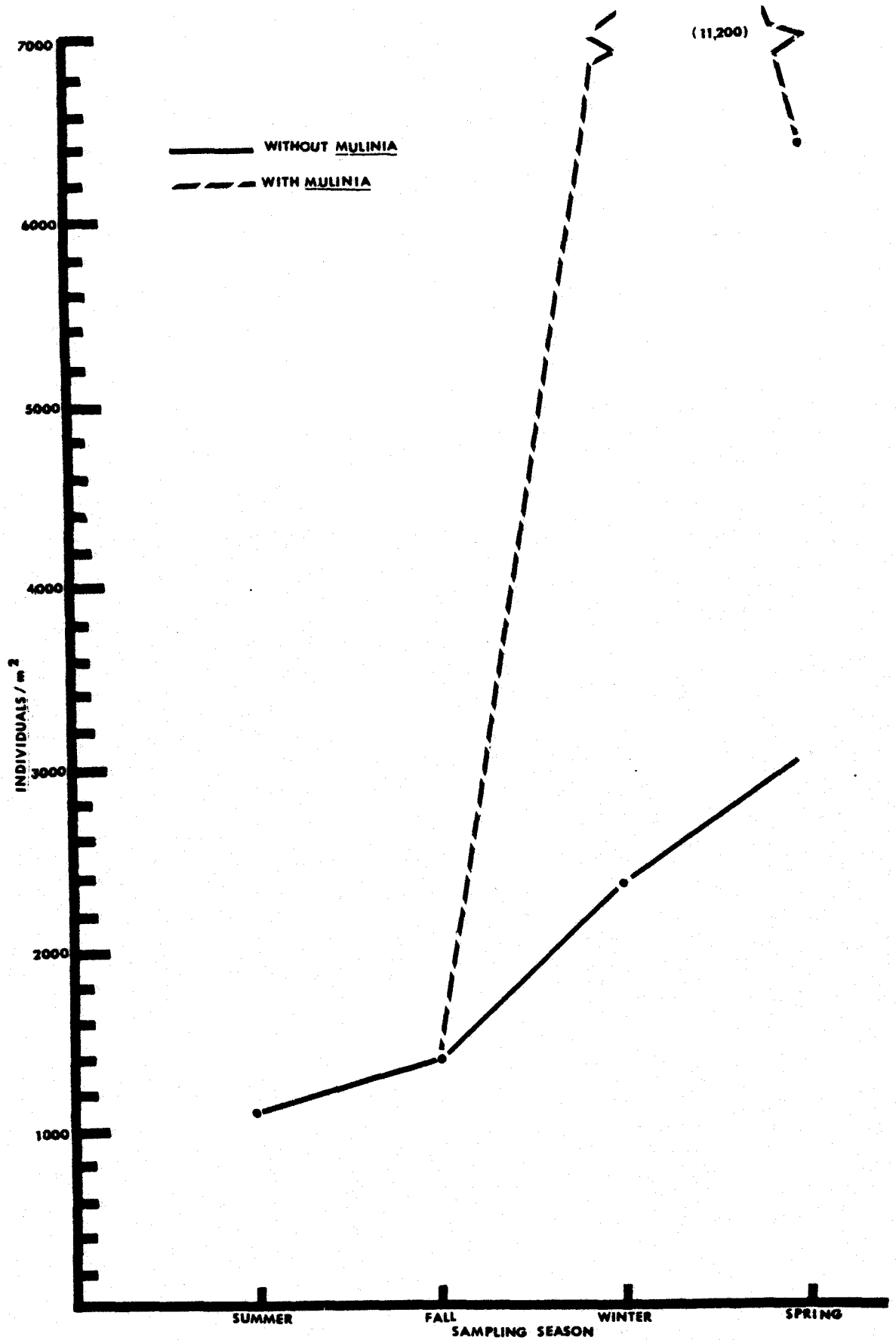


Figure 8. Mean number of megafaunal individuals per square meter (3 samples per station) at West Hackberry site. Plotted by seasons.

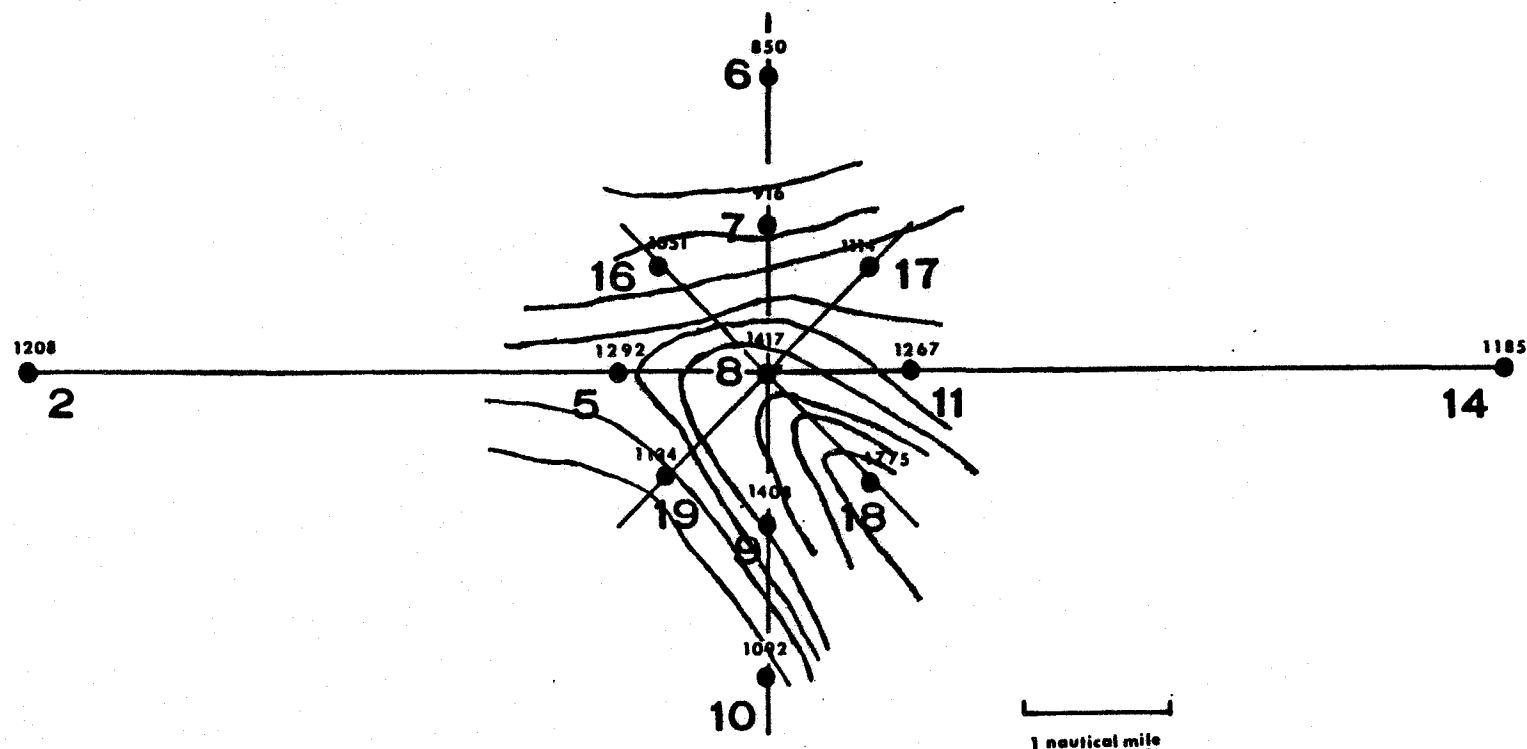


Figure 9. Mean of the total number of megafaunal individuals counted (minus Mulinia lateralis) per station, West Hackberry site--95% confidence interval for mean 1064-1352. Considering the irregularity of the isopleth surface, the map cannot be extended reasonably to stations 2 and 14. However, the trend is to lower values in the north-northwest direction.

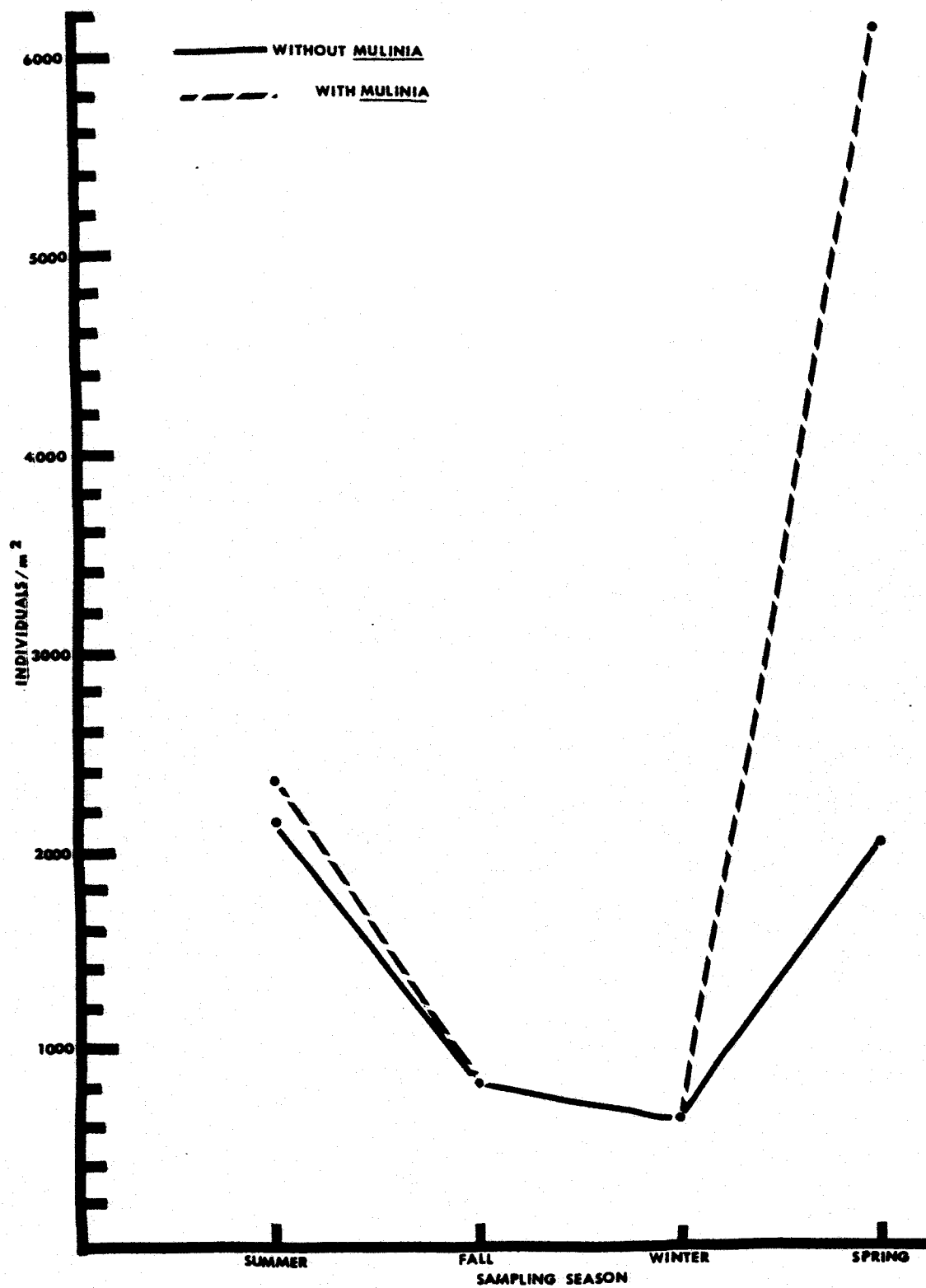


Figure 10. Mean number of megafaunal individuals per square meter, by season, for the Weeks Island site.

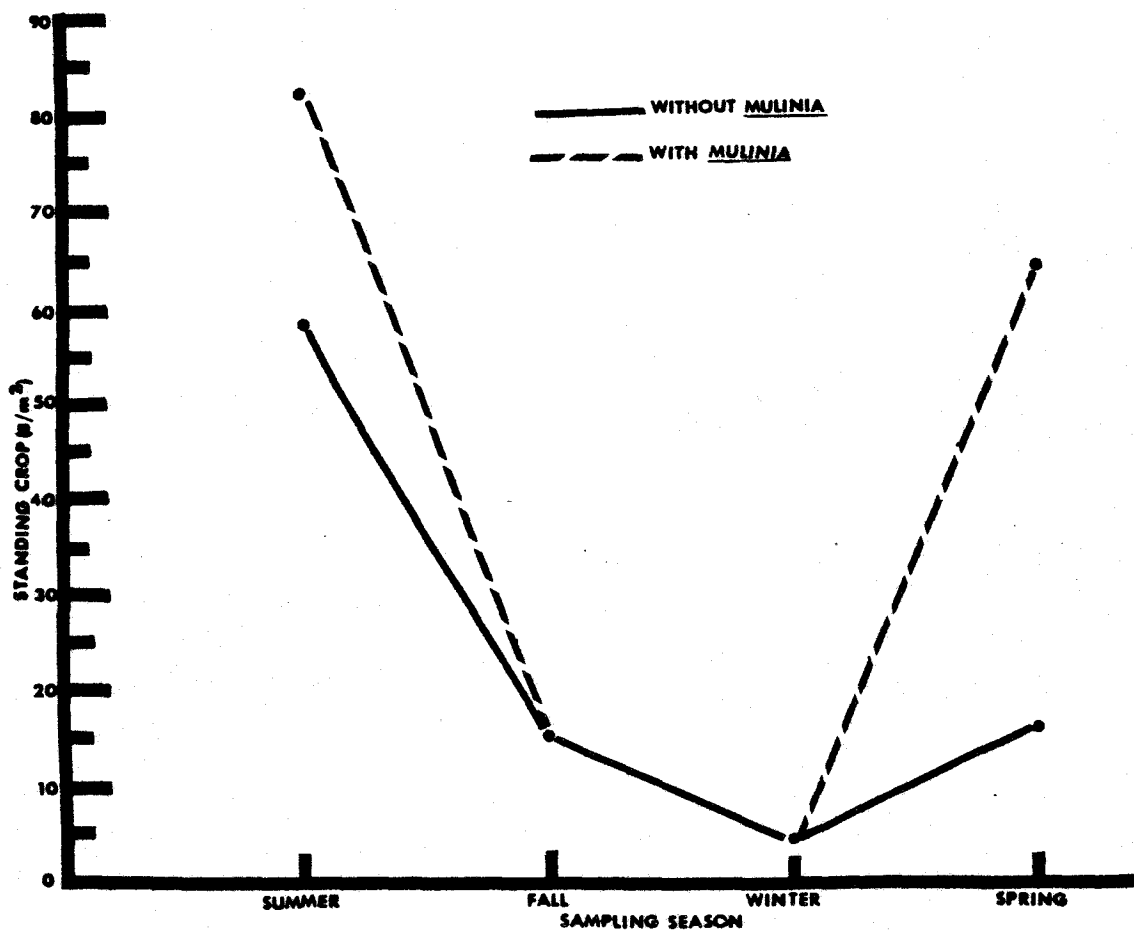


Figure 11. Mean biomass or standing crop as grams per square meter (g/m²) of megafauna at the Weeks Island site.

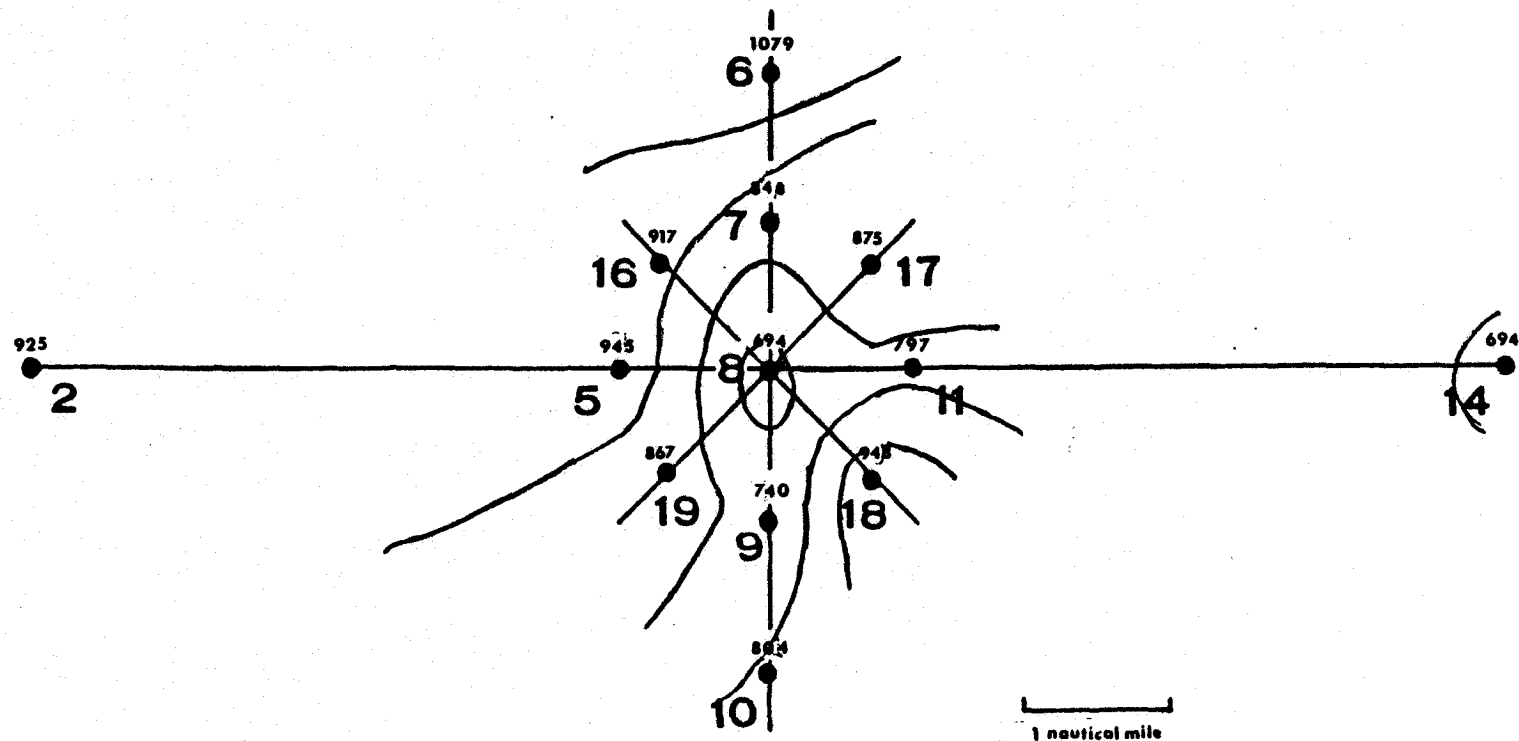


Figure 12. Mean of the total number of megafaunal individuals counted (minus *Mulinia lateralis*) per station, Weeks Island site--95% confidence interval for mean 786-926. Considering the irregularity of the isopleth surface, the map cannot be extended reasonably to stations 2 and 14. However, the trend is to lower values in the east-southeast direction.